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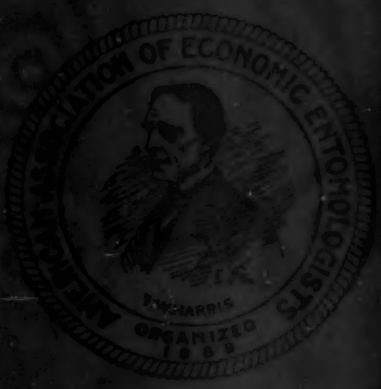

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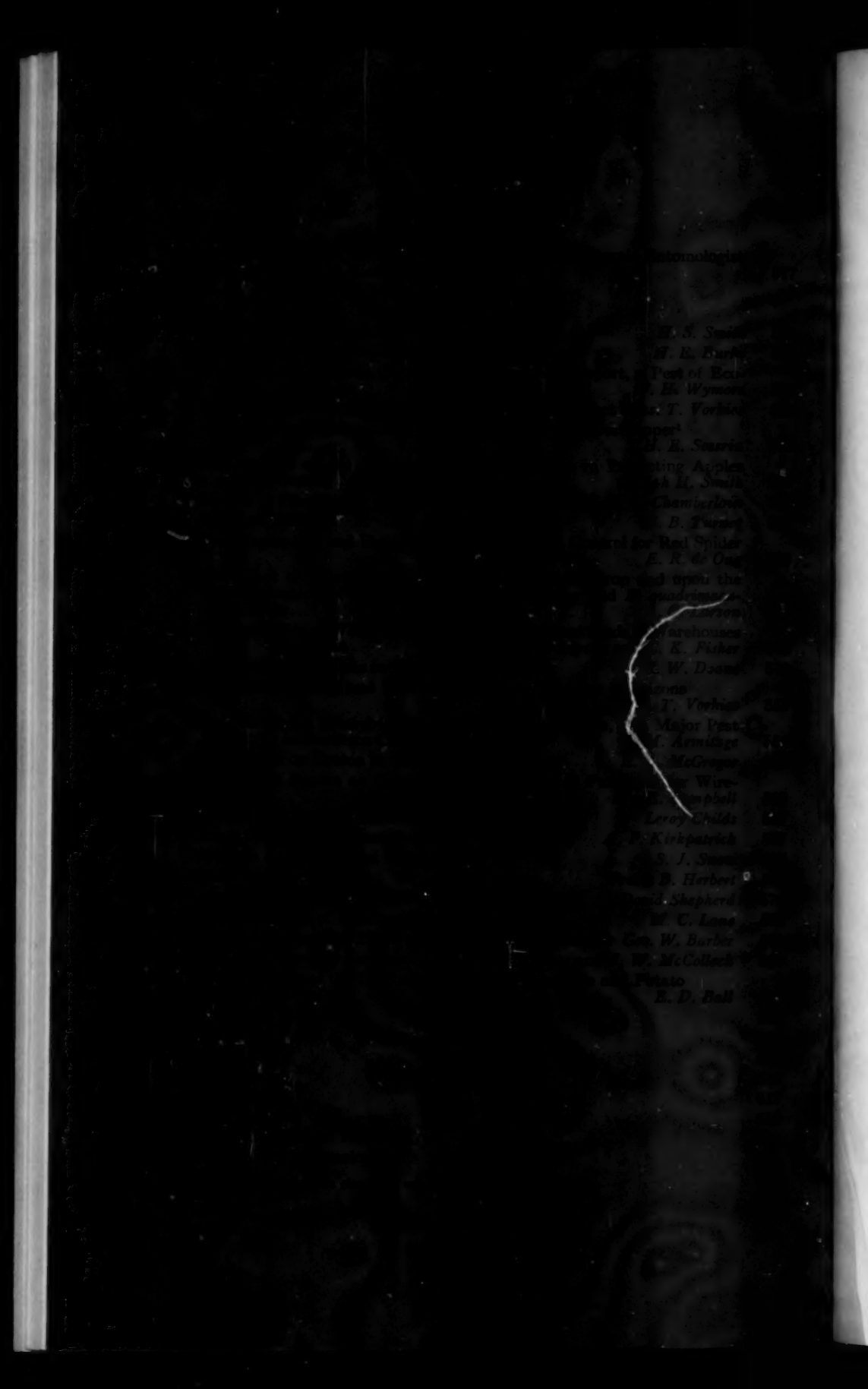

JOURNAL
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VOL. 17 OCTOBER, 1924 No. 5

Proceedings of the Ninth Annual Meeting of the Pacific Slope Branch of the American Association of Economic Entomologists

The ninth annual meeting of the Pacific Slope Branch of the American Association of Economic Entomologists was held at Stanford University, June 27–28, 1924.

The opening and closing sessions were devoted to short business meetings, while the intervening time was occupied with the reading of papers and discussion. Following the Friday afternoon session the Federal and State entomologists opposed each other in the first annual championship Pacific Slope ball game. Due to a violent collision between one of the catchers and the official scorer, whose equilibrum and decorum were entirely upset, the official score was lost, but it is believed that the State Entomologists were victors. After the ball game a barbecue was substituted for the usual banquet and proved to be a very pleasant innovation.

PART I. BUSINESS PROCEEDINGS

The meeting was very successful, not only in attendance and number of papers presented, but also because of so many distinguished visiting members. The following members and visitors were present:

B. N. Annand, San Mateo, Cal.
H. M. Armitage, Whittier, Cal.
E. P. Bartlam, Sacramento, Cal.
Lawrence Bruner, Auburn, Cal.
A. F. Burgess, Melrose Highlands, Mass.
H. E. Burke, Palo Alto, Cal.
Roy E. Campbell, Alhambra, Cal.
Thomas R. Chamberlin, Salt Lake City, Ut.
Leroy Childs, Hood River, Oregon.
T. D. A. Cockerell, Boulder, Colorado.
L. R. Cody, San Jose, Cal.
D. L. Currier, San Jose, Cal.
E. R. de Ong, Berkeley, Cal.
R. W. Doane, Stanford University.
Carl D. Duncan, Stanford University.
E. T. Doyle, San Francisco, Cal.
E. O. Essig, Berkeley, Cal.
G. F. Ferris, Palo Alto, Cal.
C. K. Fisher, Alhambra, Cal.
A. J. Flebut, San Francisco, Cal.
Stanley B. Freeborn, Davis, Cal.
L. O. Howard, Washington, D. C.
R. D. Hartman, Cupertino, Cal.
W. C. Jacobsen, Sacramento, Cal.

F. P. Keen, Klamath Falls, Oregon.
A. F. Kirkpatrick, Lindsay, Cal.
J. F. Lamiman, Berkeley, Cal.
A. O. Larson, Alhambra, Cal.
Arthur C. Mason, Lindsay, Cal.
E. A. McGregor, Lindsay, Cal.
C. M. Packard, Sacramento, Cal.
L. P. Rockwood, Forest Grove, Oregon.
Henry H. Severin, Berkeley, Cal.
Harry S. Smith, Riverside, Cal.
Ralph H. Smith, Berkeley, Cal.
S. J. Snow, Salt Lake City, Utah.
L. B. Soliman, Cairo, Egypt.
F. I. Spruyt, Berkeley, Cal.
A. F. Swain, Fresno, Cal.
E. P. Van Duzee, San Francisco, Cal.
Edwin C. Van Dyke, Berkeley, Cal.
Robert K. Vickory, Saratoga, Cal.
Chas. T. Vorhies, Tucson, Arizona.
H. E. Woodworth, Berkeley, Cal.
F. H. Wymore, Berkeley, Cal.
A. E. Yoder, Salinas, Cal.

Report of the Secretary and Treasurer

The membership of the Pacific Slope Branch, being those members of the parent association living in Pacific Slope States or Pacific Islands, is constantly increasing, being now 137. Since our last meeting four members have died, Mr. S. W. Foster, Mr. A. L. Lovett, Mr. R. C. Treherne and Mr. W. B. Turner. These men had all made places for themselves in their profession and their loss is keenly felt.

The financial statement is as follows:

Date	Item	Amount Paid	Balance
Nov. 9, 1923	Received from Mr. Essig		$25.64
Feb. 1, 1924	105 Mimeographed notices	$2.00	
	100 1c envelopes	1.18	
March 24	1924 assessment	5.00	
April 23	115 Mimeographed letters	2.00	
June 7	105 Mimeographed letters	2.00	
Dec. 30, 1923	Interest		.16
June 12, 1924	Conditional deposit from bank		1.00
June 25, 1924	Total received		26.80
	Total expended	14.48	
	Balance on hand		$12.32

Following a report by the membership committee there was a discussion of membership qualifications, led by Mr. Burgess, whose presence and able discussion of this, and other matters during the meeting, did much to bring the Pacific Slope Branch in closer fellowship with the Parent Association.

Chairman Smith appointed the following committees:

Nominating—R. W. Doane, C. M. Packard, C. T. Vorhies.

Resolutions—E. O. Essig, A. O. Larson, T. R. Chamberlin.

Auditing—E. C. Van Dyke, H. M. Armitage.

Membership—Roy E. Campbell.

Final Business, Friday Afternoon 3 o'clock

The final business meeting was called to order by Chairman H. S. Smith, who asked for reports of the following committees:

The Auditing committee reported the account and statement of the treasurer as correct.

The Resolution committee offered the following resolutions:

Resolved: That a vote of thanks be extended to Stanford University for the hospitality in providing the Pacific Slope Branch of the American Association of Economic Entomologists with a meeting place and accommodations for its members and that the secretary forward a copy of this resolution to the president of the University.

Resolved: That a vote of thanks be extended to Prof. R. W. Doane for his untiring efforts in making our meetings both delightful and successful.

Resolved: That a vote of thanks be extended to our Chairman Harry S. Smith for the courtesy, tact and competence with which he has conducted the meetings.

Resolved: That we express an appreciation to Dr. L. O. Howard and A. F. Burgess for their helpful interest and participation in our meetings.

The nominating committee presented the following report:

Chairman—Leroy Childs
Vice Chairman—Stanley B. Freeborn
Secretary—Roy E. Campbell

The reports were all approved as presented and following a brief statement by the new chairman, Mr. Childs, the meeting adjourned.

PART II. PAPERS AND DISCUSSION

Morning Session, Thursday June 27, 1924

Chairman Smith called the meeting to order at 10 A. M. and asked Vice-Chairman C. M. Packard to take the chair.

VICE-CHAIRMAN C. M. PACKARD: We will now listen to an address by the chairman.

SOME PHASES OF PREVENTATIVE ENTOMOLOGY

By H. S. SMITH. *Citrus Experiment Station, Riverside Calif.*

(Paper not received for publication)

At the close of the address Chairman Smith again took the chair and called for the following papers.

SOME HABITS OF THE CALIFORNIA LEAD CABLE BORER

By H. E. BURKE

(Paper not received for publication)

THE GARDEN CENTIPEDE, *SCUTIGERELLA IMMACULATA* (NEWPORT), A PEST OF ECONOMIC IMPORTANCE IN THE WEST

By F. H. WYMORE,

Division of Entomology and Parasitology, University of California

ABSTRACT

The garden centipede, *Scutigerella immaculata* (Newport), is found widely distributed throughout the world and has been studied by zoologists for many years in relation to the supposedly ancestral characters of insects, chilopods and diplopods. In recent years it has been considered by economic entomologists of California, Oregon and Utah as among the most important and destructive pests in many truck crop sections of these States. In California it is particularly destructive to asparagus shoots and seedlings of beans, peas, melons, etc., the injury being due to the pest's eating numerous small holes in the host. All stages in the life history of the little animals have been found in the intensively cultivated asparagus fields.

Paradichlorobenzene and calcium cyanide as soil fumigants have given encouraging results in controlling the symphylid and other soil pests and more extensive experiments with these chemicals are in progress. In the asparagus fields of the Delta region of the Sacramento River, flooding has proven quite practical as a control in several cases. Best results from flooding have been obtained where the fields were kept thoroughly and continuously covered to a depth of a foot or more for from two to three weeks.

The *Symphyla*, an order of *Myriapoda* to which the garden centipede, *Scutigerella immaculata* (Newport), belongs, are of unusual scientific interest. Because of their supposed primitive characteristics the animals have held the attention of many Zoologists since 1763, the year in which Scopoli described the first species of this order, viz. *Scutigerella nivea*, which he referred to the genus *Scolopendra*. In all the papers reviewed by the writer or referred to by other writers, published between 1763 and 1905, it was not even suggested by the authors that those very small symphylids might some day become an economic pest. The main reasons were, perhaps, that it was commonly supposed that the little animals were to be found only in very secluded regions and that their food consisted of microscopic animals.

According to Grassi (1886), they prefer rocky soil in shaded regions for their habitations and where there are no stones the animals are not to be found. Williams (1904) reported that they are to be found isolated beneath flat stones in the drier portions of a stream bed and in restricted areas along the body of the stream.

Williams (1907) makes the following statement concerning the habits of *Scutigerella immaculata:* "The chief factors determining their distribution seem to be an atmosphere of great humidity, a moderate tem-

perature, comparative darkness, and an undisturbed—at least uncultivated—soil."

He also suspected that the garden centipedes fed partially upon vegetable matter and conducted certain feeding experiments. One of these showed that in captivity the animals survived much better when kept in an environment of damp, decayed leaves. In his summary and conclusions, however, he states, "*Scutigerella* is probably carnivorous."

In certain localities in California, Oregon and Utah evidence of their feeding habits and their habitat in cultivated fields is plain enough. *Scutigerella immaculata* (Newport) has proven to be a real pest to asparagus in California on the various islands in the Delta section of the Sacramento River. Asparagus growers report that twenty years ago several fields of asparagus on Grand Island had to be plowed out because of these animals which were wrongly supposed to be wireworms. The first published account of the garden centipede work appeared in Bulletin 165, California Agricultural Experiment Station, April, 1905. This bulletin includes an illustration showing the nature of the damage done to asparagus shoots and a description of the pest under the name wireworms.

The first record we have of economic injury directly attributed to this pest is a paper by Woodworth (1905). In this paper he describes the centipede as a new species, *Scolopendrella californica*.[1] Quoting from the above paper, "It was first noticed, as far as can be learned, some three or four years ago in the large asparagus fields on Boldin Island and about Sacramento, and proved to be a pest of a very serious kind."

In the winter of 1912–1913 the asparagus farmers of the Delta section of the Sacramento River urgently appealed to the University of California for assistance in controlling the garden centipede. Much work was done at this time by E. R. deOng in testing out repellents and soil fumigants of which carbon disulfid proved effective but was not practical. No further attempt was made to control this centipede until the fall of 1922. At this time another urgent appeal for assistance in controlling this pest was made to the Division of Entomology and Parasitology by the asparagus farmers of the Delta country, representing approximately forty thousand acres of asparagus. To the writer was assigned the

[1]In a letter from Dr. R. V. Chamberlin, Museum of Comparative Zoology, Cambridge, Mass., concerning specimens of the symphylids sent to him from California, he states, "These specimens are *Scutigerella immaculata* (Newport). I find no variations that I regard as significant in comparison with typical representatives from Europe."

problem of studying this pest in the field and developing a practical method of control if possible.

Observations and experiments have been continued throughout the past two years, most of the work being done on the large asparagus ranch of the California Packing Corporation on Ryer Island in the Delta region of the Sacramento River.

DISTRIBUTION. According to Hansen (1903) members of the order *Symphyla* have been found in Europe, Algeria, Cape Colony, Venezuela, Chile, Southern Brazil, Patagonia, Java, Sumatra, Siam, India, Mexico and Northeastern United States.

Previous to 1903 there had been but four accepted species of the *Symphyla* described in the 138 years that had elapsed since Scopoli in 1763 described the first species known as *Scutigerella nivea*. These four species had been found only in Europe and in the United States. To quote from Hansen, "I venture to state that species of this group can be captured in all countries of the world with the exception of the Arctic and Antarctic regions."

After studying twenty-four species, Hansen is of the opinion that *Scutigerella* is distributed a little nearer to the polar regions than *Scolopendrella*. He also believes that more species of *Scolopendrella* than of *Scutigerella* will be found in warmer regions. He states that with the exception of *Scutigerella immaculata* the distribution of all the known species must be regarded as moderately limited. This species in 1903 was known to be distributed from 60° latitude North, throughout Europe, including Sweden, Denmark, England, France, Germany, Austria and Italy. In Africa it was known in Algeria; in South America, in Buenos Aires, Argentine; in North America, in Cordova, Mexico; and in the United States, in Massachusetts, Kentucky and Texas. It has since been found in six other states of the United States, including Ohio, Georgia, Colorado, Utah, California and Oregon.

Where it occurs in California, Oregon, Utah the garden centipede has been particularly destructive to truck crops.

In California it has been quite destructive in certain parts of Yuba, Humboldt, Sonoma, Yolo, Sacramento, San Joaquin, Ventura, Santa Cruz, Santa Barbara and San Bernardino counties; in Oregon, in Lane, Umatilla, Yamhill, Clackamas, Jackson, Linn, Multnomah, Marion and Benton counties; in Utah, in Davis and Juab counties.

DESCRIPTION. The garden centipede, *Scutigerella immaculata* (Newport), is ordinarily a small white creature but often the body is tinted by the colored food material in the digestive tract, e. g. when feeding on the

tender white asparagus shoots the animals are almost transparent white, while red radishes give a pinkish color; garden beets, a deep red; and decayed vegetable matter and so forth, a brownish color. The adults vary in length from 2.7 to 6.7 mm., are equipped with 14 chitinous plates or scutes on the dorsal body wall, and back of the fourteenth scute is located a pair of cerci in the tips of which are found the openings of the two spinning glands; they have one pair of many-jointed antennae, an eye-like body just back of each antennae, four pairs of mouth appendages; twelve pairs of well developed legs, the first pair four-jointed, all the rest five-jointed. At the base of each leg (excepting the first two pairs) near the coxal sac is found a small appendage (parapod) which is considered by some authors as a rudimentary leg.

The genital opening is located on the ventral side between the fourth pair of legs. The last body segment bears a pair of sensory organs out of which projects a long seta or sensory hair several millimeters in length.

HABITAT. As was mentioned above, *Scutigerella immaculata* until 1905 was supposed to occur only in isolated regions under leaves, rocks, logs, etc. During the last two years the writer has been able to find the adults in the soil about the asparagus crowns or in an intensively cultivated garden in the Delta region any season of the year. During the months of May, June and July, however, the young greatly outnumber the adults.

As the surface soil dries out in the late summer after the cutting season (after July first), the little animals migrate downwards always keeping in the moist earth.

EGGS. The eggs of *Scutigerella immaculata* are laid in clusters of from four to twenty, in the runways of the little creatures. The eggs have been found in the asparagus fields as early as March second and as late as August seventh. They are most numerous during May and June.

When first laid the eggs are a pearly white and as the time for hatching approaches they become a dirty white color. They are 2/5 to ½ mm., in diameter and are covered with tiny ridges giving the appearance of a network.

LARVAE. When first hatched the larvae are hairy little creatures varying from .9 to 1.1 mm., in length, have six pairs of legs, six-jointed antennae and nine scutes. As in the adult, the first pair of legs has four joints, while all others are five jointed.

Williams (1907) in his observations of *Scutigerella* in Ohio found the newly hatched larvae to possess seven pairs of legs. There is a possible error in his work in that his observations were made about four days

after the larvae had hatched, and according to the writer's observations, the young molt for the first time three or four days after hatching.

In many respects the larvae with six pairs of legs are different from more mature forms: they are not so lively, their movement being more like that of the members of the family *Poduridae* than the adult *Scutigerella;* the scutes instead of being notched, are rounded posteriorly and possess numerous long setae; the cerci turn down and the spinning apparatus apparently does not function, and the second antennal joint is cylindrical in shape and twice as long as the normal urn-shaped joints. After the first molt, however, the little animals with seven pairs of legs become fully as active as the adults, and the scutes, although no more in number than before molting, take on the normal shape of those of the adult; the cerci function normally and the antennae become thirteen jointed, and in appearance and function are like those of the adult only they are shorter.

Growth takes place by the intercalation of a pair of legs and a somite just in front of the last somite, that which always bears the sense organs.

Food Plants. The tender shoots of asparagus, the germinating seeds of lima and common beans, vetch, peas, muskmelons, cucumbers and the succulent roots of sugar beets, garden beets and radishes have, in certain localities of California, been the principal hosts of this garden centipede. They also have been found attacking the fleshy roots of corn, morning glory, wild mustard, rhubarb, alfalfa, wild lettuce, needle grass and foxtail, but only to a limited degree.

In Oregon and Utah, however, it has in certain localities kept all vegetation from growing. In a letter dated August 31, 1923, I. M. Hawley of the Agricultural Experiment Station, Logan, Utah, concerning the garden centipede states as follows: "I consider it our worst pest in the State as it is in our main truck section in Davis County where land is very expensive. It is not uncommon to plant most any kind of seed two to five times and have them take it every time. I have seen an asparagus bed where it killed it completely and even weeds could not get a start." A. L. Lovett of Oregon Agriculture College, Corvallis, Oregon, in a letter dated November 23, 1923, makes a similar statement of its work in Oregon, as follows: "It seems to be rather erratic, occurring in such numbers in limited areas as to destroy all sprouting seeds, even keeping patches cleared of weeds."

While the little animals seem to thrive on an abundance of succulent plant food, the writer has found them to exist very well for several months where no succulent material was present, and has been able to

keep live specimens in a small tin box containing moist earth for as long as nine or ten months.

NATURE OF INJURY. The garden centipedes feed beneath the surface of the soil eating numerous small holes in the host.

FLOODING. Among other suggested methods for control of the garden centipede, E. O. Essig in Circular No. 204, University of California Agricultural Experiment Station, suggests flooding as a possible means of control of this pest. After many attempts with the use of insect repellents for the control of the centipedes had failed, Ed. Shelley, a farmer on Grand Island, in 1921 made an attempt at flooding. Although the small temporary levees used in this experiment did not hold the water on the field long enough to drown all the symphylids, Shelley found that the infestation was greatly reduced the following season. The experiment was repeated the next winter, 1922–1923, and this time he succeeded in thoroughly flooding small areas on his farm for three weeks. The writer kept a fairly thorough check on this field during the growing season of 1923 and could not find any trace of the symphylids on the well flooded plots and found that the numbers were greatly reduced on areas where the land had been partially covered.

After discussing the results of this experiment with officials of the California Packing Corporation Land Department, it was decided to prepare for flooding 500 acres of the infested area on their large asparagus ranch on Ryer Island. It was necessary to construct over five miles of levee to hold the water on this acreage. To furnish the water, three 12-inch pumps were kept running day and night pumping water from the river into irrigating canals on the ranch. Due to a mistake in checking-up on the level of the field, only about 450 acres were thoroughly flooded. Where the ground was covered only about six inches deep not quite 100 per cent control was secured, but where it was covered to a depth of a foot or more, no centipedes have reappeared to date, which at present would seem to mean extermination.

SOIL FUMIGANTS. Various experiments were conducted with soil fumigants during the past two years for the control of the garden centipede in the asparagus fields on Ryer Island. Paradichlorobenzene and orthodichlorobenzene and calcium cyanide were tested under a number of different conditions. Paradichlorobenzene proved very efficient in killing the little animals when one ounce of material to three linear feet was scattered along on both sides of the asparagus row, a garden hoe being used to make the furrows close to the crowns. This experiment was conducted during the latter part of May when there was yet considerable

moisture in the soil, and at a soil temperature of 56°F. Later experiments with part of the material applied with a beet seeder and part plowed in with a garden plow when the soil had become drier, were not nearly so efficient. Further experiments with paradichlorobenzene and calcium cyanide are now in progress, the material being applied soon after leveling the ridges.

REPELLENTS. Upon the suggestion that insect repellents might be effective for the pest in the asparagus fields, many materials such as various forms of lime, tobacco dust and others were tested, but without any apparent repelling effect. These materials were scattered along on top of the asparagus crowns and covered with a heavy ridge of dirt. Some work has also been done and other experiments are being planned with the use of repellents for the protection of sprouting seeds, bulbs and so forth, in the small gardens and truck crop fields.

A discussion followed, lead by Mr. E. O. Essig, who emphasized the importance of the entomologist having a better understanding and knowledge of the best farm practices.

CYLINDROCOPTURUS JATROPHAE FALL, A NEW ECONOMIC INSECT

By CHAS. T. VORHIES, *University of Arizona, Tucson, Arizona*

ABSTRACT

Serious damage to chrysanthemums in one garden in Tucson, Arizona, by a small stem borer proved to be due to a hitherto unrecorded insect pest. This was identified as *Cylindrocopturus jatrophae* Fall, first discovered by Schwarz on *Jatropha* in the Santa Catalina Mountains. *Jatropha* is a native shrub of the family Euphorbiaceae.

Late in July 1923, a citizen of Tucson, Arizona came to me with the complaint that his chrysanthemums were being mysteriously killed, and the statement that he suspected some insect of doing the damage, though he was at a loss to locate anything specifically. An examination of his chrysanthemum bed showed a number of the plants in various stages of wilting and dying. When it was attempted to pull up plants that were badly wilted or quite dead they would usually break off below the surface of the soil. It was found that the stems were being mined by some small borer, and on careful examination boring larvae, a pupa or two, and two adults were found within the tunnels of the stems. So far as could be determined with the small amount of material available it appeared that the eggs were probably laid in pits dug in the bark at the surface of the soil. The larva then mines back and forth upward

and around, but not necessarily completely encircling the stem, and seems to at times go into the stem to or through the center. It appeared later to work downward gradually and by the time it is full grown is making a frass-filled tunnel nearly 1 mm. wide. Pupation as observed occurred in the central pith, but whether always so cannot be stated. The plant is so weakened by even one larva as to break off readily, usually at a point an inch or more below the soil surface, leaving a few roots above the point of breakage. One fresh pupa was observed to transform into the adult in one week. Stems infested with two or more larvae are likely to have a swollen portion above the breakage point with the bark broken and having a diseased appearance. The stem may be so riddled as to be readily broken through at this swelling. From one rather large infested stalk examined with reference to depth of penetration it was found that none had penetrated more than two or two and one-half inches below the soil level.

Specimens sent to Washington for identification were determined by Schwarz to be *Cylindrocopturus jatrophae* Fall., of the sub-family Zygopinae, family Curculionidae; and the further surprising information was secured that it was first found by Dr. Schwarz himself on the south slope of the Santa Catalina Mts., some 15 miles from Tucson, on the stems of *Jatropha macrorhiza*. I say surprising, because *Jatropha* is a Euphorbiaceous shrub, quite unrelated to Chrysanthemum. A recent examination of *Jatropha* plants disclosed that some of the stems of each clump were dead, and these were found to be mined extensively at the crown with frass-filled tunnels closely resembling those found in the damaged Chrysanthemums. No specimens were found at this time. No further infestation in the affected plot has yet been observed this season. This infestation was the only one that came to the writer's attention last summer, though chrysanthemums are quite commonly grown in Tucson. Furthermore, this occurred only one city block, actually about 360 feet, from the writer's chrysanthemums which were unaffected. Whether further infestations occur will be a matter to watch with interest. The nearest probable occurrence of *Jatropha* to the city would be at a distance of about three miles, in the Tucson Mountains.

FACTS CONCERNING PERIODICAL OUTBREAKS OF THE BEET LEAFHOPPER

By H. E. SEVERIN, *University of California, Berkeley, California*

(Paper not received)

The session adjourned at 12:10 P. M.

Afternoon Session, Thursday June 27, 1924

After viewing two interesting and instructive motion pictures on Forest Insect Control and Malaria and the Mosquito, the meeting was called to order by Chairman H. S. Smith, and the following papers presented:

EXPERIMENTS ON THE EFFICIENCY OF LEAD ARSENATE IN PROTECTING APPLES AGAINST CODLING MOTH INJURY

By RALPH H. SMITH, *Berkeley, California*

(Paper not received)

STUDIES OF PARASITES OF THE ALFALFA WEEVIL IN EUROPE

By T. R. CHAMBERLIN, *U. S. Bureau of Entomology, Salt Lake City, Utah*

(Paper not received)

CHAIRMAN H. S. SMITH. We will now call on Mr. Packard to read a paper by W. B. Turner.

MR. C. M. PACKARD. This paper was prepared to record the last work done by Mr. Turner prior to his fatal illness.

THE TULE BILLBUG

By W. B. TURNER,[1] *Scientific Assistant, U. S. Department of Agriculture, Bureau of Entomology*

ABSTRACT

The adult Tule Billbug sometimes injures small grains in California by eating into the stems near the head. The immature stages have been found only in the rootstocks of the tule. There is only one annual generation. The eggs are laid in spring and in early summer, in the mud surrounding the tule roots and sometimes in the tule stems. They hatch in 10 to 13 days. The larvae burrow in the rootstocks during summer and fall, pupating in cells formed at the end of their burrows in fall or early winter. Some change in about 20 days to adults which hibernate in the pupal cells and some hibernate as pupae. Adults emerge in spring and are abroad until late summer. They are strong fliers. Eradication of the tules is the only known means of control.

[1]The writer wishes to acknowledge with thanks the material assistance of Messrs. C. M. Packard and B. G. Thompson in securing the information upon which this paper is based.

Introduction

Extensive injury to corn, sugar cane, small grains and grasses by the group of insects known as billbugs frequently occurs in many parts of the United States, especially to plantings on newly reclaimed swamp lands. In California such damage is much less common, but injury to small grains by a species locally known as the "tule billbug"[2] is occasionally reported, and these instances seem to warrant the publication of such information as has been secured concerning that insect. So far as the writer has been able to learn no detailed observations of this billbug have ever been carried through, even for one season; and for this reason an effort has been made to learn something of its life history in Central California.

Distribution

While the tule billbug has come under the writer's observation only in the Sacramento-San Joaquin delta lands and the lower Sacramento Valley, its distribution probably coincides with that of its native food plant, the large rush known locally as the tule,[3] which is found throughout California. Leng lists (*Sphenophorus*) *Calendra discolor* only from California in his Catalogue of Coleoptera of North America.

Character of Damage to Growing Grain

The injury is the result of the feeding habits of the adult. With the long proboscis the billbug eats into the stem of the plant in the boot, or a few inches below the head in more mature grain. The appearance of the plant attacked is conspicuous and readily recognized, the stem being nearly or completely eaten through, the head becoming whitened or bleached and without kernels or with shrivelled kernels, depending on whether the injury occurs before or after the grain is formed, and the plant rendered worthless except for forage. Barley has suffered the greatest damage by this insect; but injury to wheat and oats has also been observed. So far as known the larvae under field conditions feed only in the rootstocks of the tule and never on the roots of cultivated crops; though A. F. Satterthwait informs us, by letter, that he reared them to adults in the laboratory on timothy corms and sections of corn stalk.

Description and Habits

The egg is white, with a pearly luster, slightly kidney shaped, about one-eighth of an inch in length and one-half that in its shorter diameter.

[2] *Sphenophorus*) *Calendra discolor* Mann.
[3] *Scirpus occidentalis* Chase.

They are deposited separately in the mud in which the tules are growing and occasionally in incisions in the stems of that plant, the great majority being in the former situation. Of 50 eggs secured in the laboratory 35 were laid in the mud at the bottom of the cage. Under more normal conditions the percentage of eggs deposited in the tule stems probably would have been much smaller. Oviposition in the wet soil surrounding the rootstocks undoubtedly is the more common habit. Examination of many of the aerial stems has never revealed any evidence of the larvae feeding therein, and in the dissecting of over 200 pieces of rootstock bearing many times that number of bases of stems only one such base showed the feeding burrow of the descending larva. In this single instance the adult, very small and much distorted, was found dead in the pupal cell in the rootstock.

The newly hatched larva is but slightly larger than the egg, and of the typical burrowing weevil larva shape, pearly white in color, with dark brown head and mandibles. The fullgrown larva is about ¾ of an inch in length and more than half that in diameter, with small brown head, the body white and very much wrinkled. The larvae, on hatching, burrow into the succulent rootstocks, making tortuous tunnels running mostly longitudinally, which steadily increase in diameter. The burrows are filled with masticated fragments of the rootstock. When full grown the larva slightly enlarges the burrow into a smooth walled cell in which pupation takes place. The pupal cells usually are located in the upper portion of the rootstock near the base of an aerial stem, inclined upwards, with the scaly epidermis of the root forming a thin cover over the upper end of the cell.

The newly formed pupa is of a pearly white color, slightly less than the fullgrown larva in size. Just before transforming to the adult the pupa shows a decided pink tint on the thorax, changing to a light brown on the thorax of the newly emerged adult, the wing covers of the latter being creamy white, with reddish lines, the margins being decidedly red.

The adult changes to a very dark reddish brown, nearly black, with light markings on the sides and under surface, from three to five days elapsing before the full coloration appears. The proboscis is about the length of the head and thorax. The adults vary in size from five-eighths to nearly an inch in length, the average being about ¾ of an inch, exclusive of the snout. They are strong fliers, mounting high into the air with a rapid steady flight, and individuals are often found miles from any tule beds. They are sometimes present in large numbers during the

spring and summer among the tules in which the immature stages have developed.

Characteristic cavities are made by the adult in feeding on the tule stems. The incision is elliptical in shape, nearly a quarter of an inch long and half as wide, readily recognized after once having been seen. Underneath this comparatively small opening examination will show that a cavity has been excavated in the coarsely cellular body of the stem, often an inch in length and half as wide. Evidently the adult eats out all the tissue within reach of its proboscis from the original incision. Caged adults were voracious feeders on the green tule stems with which they were provided.

We have some evidence to indicate that the rootstocks of tules which are standing in water all or a considerable part of the time do not become infested.

Life History

The eggs require from 10 to 13 days for hatching. The average period for incubation for 30 eggs under observation during May and early June, 1922, in an unheated room at Sacramento, was 11 days.

Larvae reared in the laboratory attained their full development in about 100 days, during which period they molted four times, including the last cast on entering the pupa stage. An average larval period of 98.4 days is afforded by the records of fifteen larvae reared in the Sacramento laboratory during the summer and fall of 1922.

The pupal period of specimens reared in cages in an unheated room during the fall of 1922 averaged 20 days, varying greatly. Thirty-six pupae in the rearing cages, from which the above average was computed, varied from 10 to 31 days. Five became adult in 18 days, five in 23 days, three in 15, three in 16, three in 17 and three in 22 days, the remainder in from 10 to 31 days. One month is not the maximum pupal period, however, since our observations show that under natural conditions a large proportion of individuals hibernate as pupae.

Seasonal History

There is but one generation a year. The earlier maturing individuals spending the winter months as adults in the pupal cells, and the later maturing ones hibernating as pupae or even larvae. We have no evidence to indicate that adults winter over outside the tule roots, or to show the proportion of hibernating larvae and pupae which mature successfully after hibernation. In the field adults which evidently had

cast off their pupal skins shortly before, were encountered in the pupal cells September 8. In the Laboratory rearing cages adults were first observed on September 20. Emergence from hibernation begins with the first warm days of spring, the beetles having been observed in large numbers on April 6. Attempted copulation was first observed in outdoor cages on March 20, 1922. The first eggs were noted in the Laboratory cages May 1st. In the field newly hatched larvae were taken on June 14. Egg laying continued in the rearing cages until July 5, and eggs were collected in the field August 17. During 1921 larvae were taken in the field on various dates from June 14 up to and including November 23. In 1924 occasional live larvae were still present in tule roots dug from a slough March 10. Pupae are to be found in the field over a long period, having been first observed in the field on September 13, and on many subsequent dates as late as April 25. In the Laboratory pupation was first noted September 12, the latest pupation date was November 7, and all specimens became adult by early December.

Control

So far as known the tule is the only plant in which the immature stages of this billbug normally develop; therefore it is rapidly reduced in numbers where the tule beds are eradicated by drainage and cultivation. Material damage occurs only in the earlier years of such cultivating of reclaimed lands. Being strong fliers the adults are likely to reestablish colonies where the tules are allowed to re-occupy the banks of drainage canals and ditches and thus afford breeding places for the billbug. Under such conditions slight injuries to grain might continue to occur. Eradication of the tules is the only means of control.

Just before adjournment Prof. E. O. Essig made an announcement in regard to the new journal, the Pan-Pacific Entomologist, which was started to fill the need of an organ in which could be gathered together the results of scientific entomological research in the Pacific region. He appealed for hearty support from all.

Friday Morning Session, June 29, 1924

Chairman H. S. Smith called the meeting to order at 9:30 A. M. The following papers were presented.

THE PREPARATION AND USE OF COLLOIDAL SULFUR AS A CONTROL FOR RED SPIDER

By E. R. DEONG, *University of California*

ABSTRACT

Two types of colloidal sulfur have been prepared, (1) by running hydrogen sulfide into a solution of sulfur dioxid; (2) by precipitating lime-sulfur solution with acid. The former (hydrophilic collodial sulfur solution) shows the finest stage of division of sulfur particles. The latter (hydrophobic colloidal sulfur or precipitated sulfur) has a coarser sulfur grain which precipitates in a few days. The sulfur particles in both of the colloid forms are smaller than those of high grade dusting sulfur and hence oxidize more quickly, making them more active in the control of red spider than other forms of sulfur. Comparison of the toxic properties of the collodial solutions with a two per cent lime sulfur solution containing 0.6 per cent sulfur showed that the former were more effective especially at low temperatures. The addition of five pounds of ground or flowers of sulfur will probably prolong the length of time which such solutions would remain effective both as acaricides and fungicides.

While testing the ovicidal action of lime-sulfur solution on the eggs of *Bryobia praetiosa* Koch, a few years ago, it was noticed that although but 50 to 60 per cent of the eggs were ever killed, yet the majority of the mites hatching from the treated eggs died within a few days. This work was done in the early spring when the maximum temperature ranged from 50° to 65°F., temperatures at which ground or sublimed sulfur has little acaricidal effect. This led to the thought that the precipitated sulfur (hydrophobic colloidal sulfur) from the lime sulfur solution was more active than the coarser forms of sulfur. Attempts made at this time to prepare sufficient precipitated sulfur or the hydrophilic form of colloidal sulfur for experimental purposes failed. Developments in the preparation and partial stabilizing of colloidal sulfur solutions have come rapidly in recent years. The great difficulty in handling such solutions is the tendency of the minute particles to aggregate or grow in size especially in the hydrophobic form. This is a serious criticism for the great advantage of such types of solution is the fineness of the particles. The use of a buffer type of colloidal solution such as glue or gelatine retards this tendency, but even then the hydrophobic form has largely precipitated out within a few weeks.[1]

The usual distinction made between a precipitated (hydrophobic) sulfur and a true hydrophilic colloidal solution is largely in the size of the particle. When first formed the colloidal particles show the Brownian movement and the majority of those which are visible under a low power

[1]H. C. Young. The Toxic Property of Sulfur. Crop Protection Digest Bul. 3, June 1923.

microscope range in size from three to six microns (.003 to .006 millimeter) but much of the sulfur in a true hydrophilic colloidal solution is not within the range of visibility at such magnification. Very few particles even of the size noted are visible. After the solution had stood for 21 days, the range in size of particles was from 6 to 30 microns. At this stage precipitation of sulfur is very noticeable. Ground sulfur, 95 per cent of which would pass a 200-mesh sieve, showed a range in size of 8 to 40 microns.

Preparation of Colloidal Solutions

Two methods were followed, (1) hydrophilic colloidal sulfur—made by passing hydrogen sulfid through a saturated solution of sulfur dioxid until the odor of the latter cannot be distinguished. The latter point is important, or if free sulfur dioxid remains in the solution, it is much more apt to burn foliage. Solutions made in this way gave approximately 3 to 7 per cent sulfur by analysis. It will be seen in Table I that this is a very stable preparation in which the particles grow or aggregate but slowly. (2) The second method of preparation (hydrophobic colloidal sulfur) is by precipitating lime sulfur solution by adding concentrated hydrochloric or sulfuric acid. (Phosphoric acid offers some advantages but is more expensive.) The acid was added to the solution to a point of acidity as shown by methyl orange, it usually requiring about 0.5 cc. concentrated acid per 10 cc. of lime sulfur concentrate (1.3° Baume). Such solutions show a tendency to aggregate sulfur particles up to the point of precipitation within a few days. The use of another colloid such as glue or gelatine delayed this especially if the glue solution was added before the acid. For commerical purposes add one pound of glue dissolved in water, to five gallons of lime sulfur solution, then in addition, two to four pints of concentrated acid, or until the yellow color disappears and the solution is slightly acid to methyl orange. A larger amount of glue may be used if the material is supposed to stand several days after preparation and before being used.

Properties of Collidal Solutions

It will be seen from the data in Table I that it is possible to make colloidal solutions either with a sulfur dioxid solution or by precipitating a lime sulfur solution, with acids, that have such finely divided sulfur particles that they are invisible at a magnification of 80 times. Since it is generally accepted that minute particles of sulfur are more effective

TABLE I—PROPERTIES OF COLLOIDAL SULFUR SOLUTIONS

Method of Preparation	May 16 (first day)	Dates of Observation					
		May 17		May 19		May 28	
		Grains	Microns	Grains	Microns	Grains	Microns
Saturated solution of sulfur dioxid plus hydrogen sulfide, 7.3 gm. sulfur per liter	Solution yellow, very few crystals, homogeneous, no visible particles	18 25 25 A few aggregates	17 2–7 1–2	4 8 9 A few aggregates	17 8–17 2–7	13 50 No aggregates	8–17 2–7
Unsaturated solution of sulfur dioxid plus hydrogen sulfide, 5.2 gm. sulfur per liter	Homogeneous, no visible particles	1 33 50 A few large aggregates	8 1.5–8 1–2	3 50 150	8 1–8 1–2 (barely visible)	1 50 100 A few large crystals	8 1–9 1–2
Lime sulfur solution, 5 gm. per liter plus 5 gm. glue Ppt. with hydrochloric acid	White, homogeneous, very fine particles	1 5 75 A few aggregates	8 1–8 1	9 30 6	8 1–8 1	Yellow precipitate 1 3 25	 8 2–6 1
Lime sulfur solution, 5 gm. per liter plus 1 gm. gelatine Ppt. with hydrochloric acid	Heavy precipitate	50 100 25 Numerous aggregates	8 1–8 1				
Sulfur flour 92 per cent passing a 200-mesh screen		6 14 39 64	26 17–26 8–17 7–8				

than large grains both as fungicides and as acaricides then such preparations must be more active than the finest of ground or flowers of sulfur now in use. These fine particles soon aggregate, however, and in a few days may contain many particles similar in size to the better grades of sulfur now on the market. It should be noted, however, that these larger particles formed after a few days do not represent all the sulfur present so that there may still be a large proportion of finely divided sulfur too small to be seen at the magnification at which these measurements were made. Various materials were tried as stabilizers but glue and gelatine gave the best results. The best results being obtained by

adding an amount of dry glue equivalent to two per cent of the weight of the lime sulfur solution used. The glue should always be added in solution and prior to the acid otherwise little good is accomplished.

Experimental Work

Sulfur in the colloidal form particularly the hydrophilic solution, is more dangerous to foliage even than lime sulfur solution. At high temperatures (80°–95° F.) 1 per cent and 0.8 per cent concentrations injured almond foliage, which is quite resistant to sulfur. Peach foliage was slightly yellowed at 0.5 per cent although apricot, plum, apple and orange were uninjured at this concentration over a period of two weeks. The maximum temperature during this time was seldom over 80°F.

Since sulfur has been commonly used at the rate of five pounds of the material to 100 gallons (approximately 0.6 per cent concentration), a comparison at low temperatures of the standard spray of lime sulfur 1 per cent plus five pounds of sulfur and colloidal sulfur solutions 0.6 per cent was made. The results given in Table II show almost perfect control for all three colloidal sulfur solutions while the lime sulfur solution plus free sulfur dropped to 90.6 per cent and the ground sulfur, to 44.9 per cent. These striking results were intensified by the low temperature at which the work was conducted and show the superiority of the colloidal form especially over dry sulfur, under conditions where sulfur in the coarser form is not very active. Experiments at higher temperatures showed less difference but even then the colloidal forms were always superior. Good control was also obtained in laboratory experiments at concentrations as low as 0.06 per cent, one-tenth that at which the data are given. The weaker concentrations offer the possibility of treatment for plants that are quite susceptible to sulfur injury. Little difference will be noted in the acaricidal value of hydrophilic and hydrophobic solutions when extended over a period of nine days; although for shorter periods the difference ranged from eleven to thirteen per cent.

Under California conditions where most of our control work on red spider is done at high summer temperatures, it is doubtful if colloidal sulfur solutions could be economically substituted for lime sulfur solution containing free sulfur, at least until an inexpensive process of manufacture is established. Finely divided precipitated sulfur either as a paste or in the dry form may be a more satisfactory form than true colloidal solutions. The latter, however, may find a place for use in the early spring or in regions where low temperatures retard the oxidation

TABLE II—COMPARATIVE TOXICITY OF COLLOIDAL AND GROUND SULFUR AND LIME SULFUR SOLUTION ON *Bryobia praetiosa* KOCH[2]

Material Used	Date Prepared	Per cent Sulfur	Observed 6/11 Adults Dead	Adults Alive	Larvae Alive	Per cent Dead	Observed 6/14 Adults Dead	Adults Alive	Larvae Alive	Per cent Dead	Observed 6/18 Adults Dead	Adults Alive	Larvae Alive	Per cent Dead
Colloidal Sulfur Solution (Sulfur dioxid and Hydrogen Sulfide)	6/9	0.6	83	19	5	77.6	213	15	3	92.3	228	...	...	100
Colloidal Sulfur Solution (Sulfur dioxid and Hydrogen Sulfide)	5/16	0.6	..	..	..	....	391	22	12	92.0	413	...	4	99.1
Fresh Precipitated Colloidal Sulfur (Lime Sulfur Solution and Sulfuric Acid)	6/9	0.6	139	70	7	64.4	463	93	11	81.6	555	1	7	98.9
Lime Sulfur Solution 2% plus 5 pounds Ground Sulfur per 100 gallons	6/9	0.6	129	97	21	52.2	267	90	50	65.6	350	7	28	90.6
Ground Sulfur (Applied as Dust)	...	...	22	65	0	25.3	70	212	56	20.7	182	110	114	44.9
Check			11	41	25	14.3	13	23	103	10.3	21	14	94	16.3

[2]Applications made June 9. Maximum temperature 6/9 71°, 6/11 71°, 6/12 78°, 6/13 72°, 6/14 76°, 6/17 72°, 6/18 74° F.

of sulfur. They also offer a very promising field as a fungicide especially for the resistant forms of fungi such as rose and grape mildew. The duration of the activity of colloidal sulfur solutions was not carefully tested. Should it be that the very fine particles such as are found in hydrophilic colloidal solutions oxidize so rapidly as to be of a temporary nature, then it is possible that the addition of finely ground sulfur to the spray might prolong its effectiveness.

THE EFFECT OF WEEVILY SEED BEANS UPON THE BEAN CROP AND UPON THE DISSEMINATION OF WEEVILS, *BRUCHUS OBTECTUS* SAY AND *B. QUADRIMACULATUS* FAB.

By A. O. Larson, *Associate Entomologist, U. S. Bureau of Entomology*

Abstract

The experimental work herein reported has been carried on for several years with the object of determining the influence of the weevily beans and cowpeas on the production of the crop as well as the probability of the infestation of the crop by weevils, *Bruchus obtectus* Say or *B. quadrimaculatus* Fab., which were contained within the planted seeds. While the planting of weevily beans reduces the yield it does not appear to have any bearing on the infestation of the succeeding crop.

That the planting of weevily beans may have an injurious effect on the succeeding crop has been emphasized very strongly by many who have written on the control of weevils. Usually the exact nature of the injury is not given.

Bremner[1] in 1910 gives the inference that the dissemination of weevils to infest the growing crop is the main, if not the only injury resulting from the planting of weevily seeds (1).

Back and Ducket[2] in 1918 said, "If seeds are planted that contain weevils, the adult weevils emerge from the seed after it has been planted and live in the field until the pods are sufficiently developed to receive the weevil eggs. They add their numbers to those in the field that have migrated from the place of seed storage. To plant peas, beans and cowpeas containing living weevils only invites a 'buggy crop'." In 1922 Back[3] said "the germination of beans, peas and cowpeas is likely to be seriously affected by the development of weevil larvae. If the embryo is destroyed by the larva, or if too much of the bean substance is eaten, the seeds can not grow."

Popenoe experimented in Kansas[4] with weevily beans as well as peas with the following results. "Fifty percent started: of these, three-fifths might have grown into plants, as the injury was restricted to the

[1]Figures not in parenthesis refer to literature cited.

seed leaves. But the remaining two-fifths were variously mutilated by the loss of a part or the whole of the germ or plumule, so that under no circumstances could they have made plants. Here then, but 30 percent could have passed the germinating stage, and these, owing to more or less considerable injury to the seed leaves, would probably have made plants of low vigor. In a check lot of perfect beans of the same varieties and in the same numbers, planted alongside, 95 percent germinated."

Razzanti[9] in Italy concluded from experiments carried out in 1917 that weevil infested beans were unsuitable for seed. He found that the percentage of unattacked beans which germinated was 84 and that of infested beans was on an average only 23.6. Plants from infested seed were weak and subject to fungus diseases and gave a smaller yield of inferior quality.

Similar, if less extensive, experiments with various kinds of peas and beans have been recorded by Riley and Howard,[5] Lintner,[10] Goff,[11] Beal,[12] and Wood.[13]

The present paper gives the results of investigation carried on by the writer (2) for several years in Alhambra, California and corroborates some of the foregoing statements and indicates that the others do not apply to the above named weevils.

Weevily Beans Defined

The term "weevily beans" is general, and may be applied to any one or all of the following classes of beans; (1) Beans containing living weevils of any or all stages, but from which no weevils have emerged; (2) Beans having no emergence holes, but containing dead weevils of one or more stages; (3) Beans from which some weevils have emerged, and in which there remain weevils, dead or alive; (4) Beans from which all weevils have emerged, and (5) Clean beans among which are a few beans of either of the foregoing classes. In this paper only those of the first 4 classes will be considered.

Germination in the Laboratory and in the Feild

During 1921 germination tests of weevily beans were made in the laboratory, and they showed that beans having as many as 9 emergence holes would germinate. The heavier the infestation the greater was the

[2]The writer received valuable assistance from Edgar Nelson, Albert H. Amis and C. K. Fisher in counting weevil holes, making germination tests and planting and caring for the growing crop, as well as in making observations of weevil injury to the growing plants.

chance that the plumule or germ would be injured, but as long as the plumule was not injured the number of emergence holes had little effect upon the power to germinate, under favorable laboratory conditions. Under less favorable conditions the weevily beans would rapidly become soft and putrid. Under similar conditions putrefaction always became apparent first in the beans containing the greatest number of emergence holes. Blackeyed cowpeas became putrid more quickly than any other variety of cowpeas or beans tried.

When planted in the field, as soon as decay began, the beans were attacked by a mite sp? which accelerated decomposition. Cold wet weather retarded the germination of the beans and seemed to furnish ideal conditions for the development of this mite, as well as for the development of the root maggot, *Egle cinerella* Fall., and other insects which aided in destroying the beans before they were out of the ground. Because of unfavorable weather conditions in 1921 many Southern California farmers were forced to replant Blackeyed cowpeas three or four times before a stand was secured. Under such unfavorable conditions beans containing weevil holes are attacked by decay organisms before the other beans, and are destroyed before they germinate or before they show at the surface of the ground. Under more favorable conditions beans having one or more emergence holes were observed to come up even while the mites were working on them. The cotyledons of such beans had rust brown spots where the mites had been at work. This color was darkest around the weevil holes.

Growth after Germination

For 5 successive years weevily beans have been planted for observation. In 1919 the writer planted Mexican red beans as follows:

100	Mexican	Red	Beans	free	from	weevil	injury.	
100	"	"	"	each	having	4 or	5	weevil holes.
6	"	"	"	"	"	11 or	12	weevil holes.
50	"	"	"	"	"	1	weevil hole.	
50	"	"	"	"	"	2	"	"
50	"	"	"	"	"	3	"	"

They were planted under favorable conditions in the middle of the garden. There was a noticeable difference in the size and thrift of plants which grew from the clean beans and from those having one hole each, the former being a little more vigorous. Likewise when comparing the plants from beans having one and two holes respectively there was a distinct difference in favor of the former. The same was true when comparing the plants from beans having two holes and those having three holes.

The difference in the size of the plants was most marked about the time the blossoms began to appear. There was not a perfect stand of the latter, and some died before producing beans. None of the beans having 11 or 12 holes came up, and only a few of those having 4 or 5 holes came up. These were small weaklings, having a struggle to exist and finally succumbed to the attack of red spider without producing beans.

In 1922 plantings of weevily beans were made as indicated in Table 2. Where possible, lots of 100 beans, free from weevil infestation, containing living weevils, dead weevils, and emergence holes from 1 to 10 or more were planted. With some varieties of beans, when it was impossible to get the desired number, a smaller number was used. There were no emergence holes in the beans containing either living or dead weevils. In some instances it was later found that all beans in these two groups did not contain weevils, as they were thought to. The tiny larvae had died immediately after making their minute entrance holes through the seed coats. It was impossible to tell before planting how many dead weevils were inside of the beans in any infested lot containing either dead weevils or emergence holes. Likewise it was impossible to determine before planting how many living weevils were within each seed in the lots containing living weevils; but by dissecting beans from each lot which was taken it was possible to determine the approximate size of the weevils in each lot.

All lots were planted the same way and at approximately the same depth in the open spaces in an orange orchard. The moisture condition was quite nearly uniform for all that were planted on the same date. The climatic conditions during the period immediately following the planting may not have been all that could have been desired, as the sky was cloudy almost constantly, with the exception of three hot days as is shown in Table 1. The humidity was high, but the temperature appears to have been high enough to insure a rapid development of young bean plants.

Table 2 shows a great difference in the number of plants that came up from different varieties, as well as from different lots of beans. It also shows that a greater percentage of the clean beans or those being free from weevil attack, came up and grew, than of the others. More plants came from beans containing living weevils than from beans containing dead weevils. This may be partly accounted for by the fact that a few more beans were later found to be free from weevils in this group than in the other. A few young bean plants were killed by cutworms and other

TABLE 1. SHOWING TEMPERATURE AND HUMIDITY DURING THE PERIOD FOLLOWING THE VARIOUS PLANTINGS, MAY 5–22, 1922

	Temperature			Humidity		
May	Max.	Mean	Min.	Max.	Mean	Min.
5	80	69	58	74	64	55
6	66	62	59	76	69	63
7	63	60	57	80	76	72
8	71	63	55	79	67	55
9	64	56	48	81	67	53
10	73	58	44	72	60	48
11	82	65	49	72	54	36
12	93	74	55	61	44	28
13	104	80	62	52	38	24
14	90	77	64	55	48	42
15	84	74	65	74	64	55
16	82	72	62	76	66	56
17	76	68	60	78	69	60
18	71	63	57	75	69	64
19	80	68	56	75	63	51
20	78	68	59	70	62	55
21	84	69	55	76	62	49
22	89	73	57	74	57	41

insects and are not included in Table 2. Eighteen, seventy-five and one-hundred per cent of the plants coming from beans having 3, 4 and 5 holes respectively, died early in the summer.

PHYSICAL INJURY TO YOUNG PLANTS

After the bean plants were up the weevil holes showing in the cotyledons were surrounded by a hard brown area. Usually the pupal cells and weevil emergence holes extended through one cotyledon and well into the other. This had a tendency to keep the cotyledons from separating properly after the bean had forced its way up out of the ground. Frequently the testa or seed coat was held firmly attached to the cotyledons by the hard brown area surrounding the emergence holes. This kept the cotyledons from spreading, thus crowding and dwarfing the primary leaves; in some instances the cotyledons would break off leaving only the hypoctyl and the early stage of the primary leaves. The food supply in the cotyledons which should have nourished the young plant while it was becoming established, was thus removed, and the plant was starved to death.

The greater the number of emergence holes there were present in the beans, the greater was the probability that decay and mites would kill

TABLE 2. PERCENTAGE OF MATURE PLANTS PRODUCED BY CLEAN BEANS AND COWPEAS AS WELL AS BY WEEVILY SEEDS*

Variety	Seeds free from infestation	Seeds infested with		Seeds containing no weevils but containing the following number of emergence holes in each seed									
		living weevils	dead weevils	1 hole	2 holes	3 holes	4 holes	5 holes	6 holes	7 holes	8 holes	9 holes	10 holes
California Pink	89	90	—	76	12	5	1	0	0	0	0	0	0
Italy's Favorite	94	—	—	—	—	18	0	0	—	—	—	—	—
Colorado Pinto	80	4	3	1	0	0	0	0	0	0	0	0	0
Red Kidney	87	—	0	33	7	0	0	0	0	0	0	0	0
Brown Kentucky Wonder	48	5	4	0	0	0	0	0	0	0	0	0	0
Cranberrys	77	6	5	0	0	0	0	0	0	0	0	0	0
Canadian Wonder	—	0	0	0	0	0	0	0	0	0	0	0	0
Superior Kentucky Wonder	—	84	79	7	0	0	0	0	0	—	—	—	—
Spotted Red Mexican	75	—	—	—	—	—	—	—	—	—	—	—	—
Refugee Green Pod	—	—	0	0	0	0	0	0	0	—	—	—	—
Lady Washington	—	—	49	6	0	0	0	0	0	0	0	0	0
Yard Long	52	—	—	5	0	0	0	0	0	—	—	—	—
Blackeyed Cowpeas	—	85	0	0	0	0	0	0	0	0	0	0	0
Holstein Cowpeas	—	—	18	91	35	2	0	0	—	—	—	—	—
Red Ripper Cowpeas	74	70	—	—	—	—	—	—	—	—	—	—	—

*Dashes (—) indicate that no seeds were planted. Zero (0) indicates that seeds were planted but failed to come up.

the plumule before the plant was up, and also the greater was the chance that the cotyledons would not be capable of separating properly after the plants were up. It was evident that decay was directly proportional to the number of emergence holes in the seed beans. Likewise, it was evident that decomposition was more rapid in beans containing dead weevils than in those containing living weevils. This may be due to the fact that the dead weevils, in all but the adult stage, decompose quite rapidly when moistened as they would be inside of a bean in damp soil. While the seed coat retarded decay the dead bodies within the bean hastened putrifaction.

Young Plants Starved

As a result of carefully weighing hundreds of Red Ripper cowpeas, the writer finds the loss in weight of the dried cowpeas is 18 to 22 per cent for 1 hole; 28 to 33 per cent for 2 holes; 33 to 38 percent for 3 holes; and 38 to 45 per cent for 4 holes, depending upon the size of the cowpeas infested and the weevils emerging. With larger cowpeas and beans the loss in weight caused by each weevil would not be so great. The greater the number of weevils there are in a bean of a given size, the smaller will be the emerging weevils, and consequently the smaller will be the percentage of weight loss per weevil.

On a normal young bean plant the cotyledons shrink in size and wrinkle up, become leathery in texture and are practically all absorbed by the growing plant. The cotyledons of a weevily bean do not shrivel and wrinkle as rapidly and the texture does not become so leathery. The transformation of the plant food is slower and the growth of the plant is correspondingly slower. The supply of stored plant food is smaller, not only by the amount actually eaten by the weevils, but also by the amount that is made unavailable around each cavity made by the weevil.

After years of experimenting with large and small beans of the same variety, Mr. A. W. LaForge of the California Bean Growers' Association makes the statement that the small beans of a given variety have a tendency to produce smaller vines and fewer pods than are produced by the larger beans. He says they also produced a greater percentage of "buckskins," or pods in which no beans mature and have a tendency to produce inferior beans. He attributes this to a more limited food supply while the plant is becoming established. The writer's observations on plants coming from weevily seed beans as compared with vines from clean beans of equal size seems to point to a similar conclusion that the

amount of stored plant food available for the young plant is a very important factor in the production of the coming crop.

Observations on the Weevils Contained in the Cotyledons After the Plants Came up

Immediately after the beans came up it was not always possible to see the weevils which were contained in the cotyledons; however, the larger weevils were visible so that daily observations could be made without disturbing them. The dead weevils were observed only to see their effect on the rate at which the cotyledons were absorbed by the young plants. Living weevils were observed to see what if any was the likelihood of their infesting the growing crop.

There were living larvae, pupae and adult weevils in lots of Pinto, Brown Kentucky Wonder, Superior Kentucky Wonder, Canadian Wonder beans, and in Blackeyed cowpeas when they were planted. There were living pupae and larvae in Red Ripper cowpeas and living larvae in Pink and Cranberry beans. None of the Canadian Wonder came up.

After the beans came up no living adults were found, although dead adults were found where it was expected that live ones existed. Living pupae were observed on different dates, but were not observed to be alive on more than two successive days. Generally the dead pupa was found in the cell, but in two instances the pupae were gone. They were undeveloped, so they could not fly. If wind or other agent had shaken them out of their open pupal cells they would have fallen into dust and dirt, where they would have perished.

On May 16th, nineteen living larvae were observed, only six of which were alive the next day, and only one survived until May 22nd, and none until May 23rd. Larvae that were not in sight on May 16th became visible later, and the more completely the larvae were covered in the cotyledon the longer they lived. This was forcefully illustrated when on May 20th a cutworm cut off a bean plant in which only one larva had been found on the 16th, the same larva being dead on the 17th. On dissecting the cotyledons of this plant two living larvae were found. One larva was found to live 9 days. The larvae shriveled up and appeared to die from starvation, whereas, the pupae and adults appeared to be killed by the excess moisture in which they found themselves when the bean had changed from its former dry condition to that of a moist growing plant.

This indicates that no weevils planted in beans will live to escape into

the field, as the cotyledons are dried up and gone before larvae could mature, and the older stages of weevils do not appear to be able to survive the change through which the bean goes. Adults may emerge from the planted bean before it has undergone much change, but the writer's observations on the length of life of the adult weevil indicate that the weevil does not live more than 2 months in the summer. These observations on the length of life of the adult weevils are born out by those of Slingerland[7] and others.

If weevils which were planted in the seed beans were able to survive the above-named hazards and get into the field alive, they would have to live more than two months before the crop would be in a condition in which it could be infested.

Oviposition in the Field

In the field the common bean weevil, *Bruchus obtectus* Say, lays its eggs in the pod after the beans are well matured, and preferably after they are ripe. It has never been observed to lay eggs on the leaves, vines or blossoms. The four-spotted cowpea weevil, *B. quadrimaculatus* Fab., lays its eggs on the pod or on the seeds after the pod has split open. With both of these weevils the great majority of the eggs are laid during the early part of their life, and the eggs laid late in the life of the female usually do not hatch.[8]

Does the Planting of Weevily Beans Invite a "Buggy Crop?"

In order to determine if possible whether or not weevils coming from late planted beans could infest crops having been planted earlier, plantings of beans other than those enumerated in Table 2 were made as follows:

April 11th, 2 rows of Black spotted cowpeas, two rows of Blackeyed cowpeas, one row each of Mexican Red, Pinto and Dutch Caseknife. Of these only the last-named variety was free from weevils. The others were badly infested with living weevils, some with *B. obtectus* and others with *B. quadrimaculatus*.

On April 12th were planted one row each of the following: Lazy Wife, Burpee's Stringless Green Pod, Extra Early Refugee, Refugee Wax, Early Mohawk, Improved Golden Wax and Brown Kentucky Wonder. Of these none were infested with weevils. The above rows were 120 feet long.

A plot about 8 by 20 feet contained volunteer Lady Washington beans which were up by April 1st. The cotyledons of these had not been

examined to determine the extent of weevil injury the seed had sustained, but they grew from beans that had been piled there, vines and all, the previous autumn for observations as to the effect of the winter weather on weevils in beans left out in the open.

May 25th, one row each of the following varieties of beans and cowpeas were planted: Brown Kentucky Wonder, Cranberry, Bayo, Mexican Red, Pink, New Era cowpeas and weevily Blackeyed cowpeas.

May 26th one row of Superior Kentucky Wonder, Ventura Wonder Wax, Eastern Cornfield, Red Valentine, and a few seeds each of Teparies, Burpee's Stringless Green Pod and unknown varieties culled from seed beans.

One row each of Pink, Mexican Red and Black Wax had been left standing all winter, and were plowed under on April 10th. These beans, remaining in the pods and being kept off the ground, were practically all filled with weevils. Many had emerged before they were plowed under.

It is thought that the different planting of beans, weevily and clean, the volunteer beans, and the beans left standing all winter, furnished a wonderful opportunity for the spread of weevils into the new crop, if it were possible for such a thing to occur in this manner. The beans were carefully watched for the presence of weevil or weevil injury. Beans were ripe by the middle of July, but there had been no weevil work observed, and later observations bore out the fact that no weevil injury had occurred.

On July 22nd, a few *B. obtectus* were liberated, and on July 24th the first weevil work was observed. A few days later some *B. quadrimaculatus* were liberated, and their work was soon noted.

Eggs laid in the laboratory in July were emerging as adult weevils in 27 to 35 days. No weevils were observed emerging in the field in any of these varieties of beans until September. This would tend to bear out the observations that no weevils had been at work in the field before those liberated July 22nd.

Observations by the writer showed that *B. obtectus* lived over the winter of 1920–21 in beans in the field near Wilmington, California, and that they lived over the winter 1921–22 at Alhambra, California. Although that was the coldest and wettest winter experienced there for years, the temperature fell only to 22 degrees F.

Weevils thus going over the winter and coming out in the spring would search for unprotected stored beans with an almost uncanny ability for finding them. Any beans or cowpeas in which they were

able to find a breeding place would serve to liberate another generation of weevils, possibly in June, and these would produce another generation extending through July and August, and these weevils would infest the ripening crop.

The writer is convinced that statements like the following "The adult weevil comes from the seed bean or pea, we plant, so by treating the seed or planting clean seed we need never be bothered."[1] or "—when one uses 'buggy' seed in which the pests are alive, one places the insect in just the best surroundings for their continued welfare;" cannot be applied to *Bruchus obtectus* Say, or *B. quadrimaculatus* Fab.

Conclusions

The planting of weevily beans or cowpeas injures the crop (1) by the injury of the germs causing a large percentage of the seeds to fail to germinate (2) by accelerating decomposition of the seeds while they are germinating (3) by holding the cotyledons together thus preventing the development of the primary leaves and (4) by removing and making unavailable much of the plant food which should aid the young plant in becoming well established thus making weak unproductive plants.

The planting of weevily beans does not appear to have any bearing on the weevil infestation of the new crop.

Literature

1. Bremner, O. E. California State Dept. Horticulture, "Destructive Insects and Their Control," Page 14.
2. Back, E. A. and Duckett, A. B., U. S. D.A. Farmers Bulletin 983.
3. Back, E. A., U.S. D.A. Farmers Bulletin 1275.
4. Popenoe, E. A. Kansas State Exp. Station Bulletin 19.
5. Riley, C. V. and Howard, L. O. Insect Life, Volume IV, page 297.
6. Razzanti, Contributo alla Conoscenza del Tonchio del Faginolo (*Acanthoscelides obtectus* Say.) Agrar. R. Scuola Sup. Agric., Portici XII.
7. Slingerland, M. V. Insect Life Vol. V, Page 86.
8. Larson, A. O. and Simmons, Perez, Biology of the Four-Spotted Bean Weevil, Journ. Agric. Res. Vol. XXVI, No. 12, Page 609.
9. Pettit, R. H. Michigan Bulletin 258, Page 38.
10. Lintner, J. A. Report of the New York State Entomologist, Vol. 7–8 Pages 257–260, 1890–91.
11. Goff, First Annual Report of the New York State Agri. Exp. Station, 1883, Page 142.
12. Beal, Country Gentleman, Vol. XLIV, Page 519. Aug. 14, 1879.
13. Wood, Theodore, Entomologists Monthly Magazine, Vol. XXII Page 114, 1885.

THE POSSIBILITY OF WEEVIL DEVELOPMENT IN NEGLECTED SEEDS IN WAREHOUSES

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(Withdrawn for publication elsewhere)

THE CONTROL OF INSECTS IN CEREAL FOOD PRODUCTS

By R. W. DOANE, *Stanford University*

ABSTRACT

Germea, cream of wheat, corn meal and other breakfast cereals are often found to be infested with insects. In an attempt to find the source of this infestation studies were made of the packages in which these cereals are packed and of the sterilizers at some of the mills, and it was found that frequently the sterilization process is not sufficient to destroy all of the insects.

At other times the cereal is subjected to a reinfestation after it has been sterilized.

A table showing various temperatures at which insects will be killed is given and a description is given of a sterilizing apparatus devised by the author with which electric heat is used to sterilize the cereal with an exposure of approximately two seconds.

At more or less frequent intervals packages of germea, cream of wheat, corn meal, rolled oats and other breakfast cereals are returned by the consumer to the dealer because these packages are found to be infested with insects. Usually the infestation is very light, but the presence of a single insect, especially if it is a larva which is spinning a web wherever it goes, is considered sufficient reason for refusing to use any of the material in the package.

Of course, the question as to the source of this infestation immediately arises. The housewife is sure that the insects did not get in the package while it was in the pantry; the retail dealer feels just as sure that the conditions in his store are not to blame, and so the responsibility is forced back upon the manufacturer who must bear the loss. Whether this is just, must, of course, be determined by a series of observations in the mills and warehouses, but our work during the last eight years has convinced us that where insects are found in well sealed packages the source of the infestation may usually be traced to the mill.

It is a common belief among many millers that some "germ" may get on the grain while it is in the field and, in some mysterious manner, survive the operations that the grain must undergo during the process of preparing it, and finally hatch out or give rise to the insect that is found in the sealed package. This belief is probably due to the fact that in the East and particularly in the South, the Angoumois grain moths lay

their eggs on the grain while it is in the field and the larvae attack the grain either before or after it is harvested, so that infested grain may be brought into the warehouse or mill. These insects attack or breed in the whole grain and are destroyed in the process of milling.

After the grain is ground it may become infested with insects at any time during its further progress through the mill to the packing table. As practically all of the cereals are superheated before they are packed all stages of the insects, if any are present, are usually destroyed by this cooking or sterilization. Sometimes, however the sterilization is not complete and some of the insects may pass on to the packing table and be sealed up in the finished package.

In one mill we found that the corn meal that was coming from the sterilizer had only reached a temperature of 140°F. This is high enough to kill all insect life if this temperature could be maintained for two hours or more, but as the corn meal goes into the sterilizer cold, and as it takes it only four minutes to pass through, it is evident that such sterilization is worse than useless, because it does little or no good and gives a false sense of security. When the steam pressure was raised from 22 lbs. to 30 lbs. the temperature of the corn meal as it came from the sterilizer was raised to 155° to 157° F. At 40 lbs. pressure the temperature of the meal was raised to 174°.

Tests made in our laboratories showed that while most of the insects in germea and corn meal were killed when subjected to a temperature of 180°F. for four minutes, a few beetles and a very few moth larvae survived the ordeal. Our tests show that to be thoroughly effective the temperature must reach 200°F. if the time of exposure in the sterilizer is to be only four minutes. If the temperature is to reach only 180°F. this should be maintained for at least 8 or, better still, 10 minutes.

After sterilization the cereal usually passes through a series of elevators, over various belts and through screens and hoppers. During much of this time it is exposed to contamination by insects. Many of the elevators and hoppers are infested with larvae practically all of the time. Some of these may be carried with the supposedly sterilized cereal to the packing table and be sealed up in the packages. Or some of the moths that are flying about at night may lay a few or many eggs in some of the exposed places and when the mill starts up next morning there is every chance of these eggs being carried directly to the packages where they will be carefully and securely packed with the cereal.

The following brief statement summarizes the results of some of the

tests made in our laboratories with Mediterranean flour moth and various species of bran beetles in all stages of development:

108° to 110° F for 1 hour killed 3-day old Mediterranean moth pupae.
110° F for 4 hours killed about one-half of " " larvae.
120° F " 4 " " all stages of " " but did not kill all of the beetles.
130° F for 4 hours killed everything.
140° F " 3 " " "
170° F " 10 minutes—Larvae of moths and beetles, and adult beetles in box with a little germea; all killed.
180° F " 4 " Killed most of larvae of Mediterranean moth in shallow pasteboard box ¼ full of germea, but some still alive even after 3 days.
180° F " 4 " Adult moths and eggs,—in open box all moths killed and no eggs hatched, moths not active after 1½ minutes
180° F " 4 " Large and small larvae of Mediterranean moth,adult moths, beetle larvae and adult beetles, all put in a revolving tin cylinder with a small amount of germea and exposed to 180° F. At end of 4 minutes all seemed dead, but after 3 days two of the moth larvae and about ½ of the beetles were still alive.
180° F " 5 " Large and small larvae of moths in revolving cylinder with some germae,—many killed but some revived.
200° F " 4 " Large and small larvae of moth in revolving cylinder with some germae,—all killed.
196° F " 5 " infested box of corn meal in oven; opened 24 hours later and some larvae still alive.
190° F " 45 " A badly infested package of corn meal which had been re-sealed after opening, was put in oven. A thermometer was put in the package so the bulb would be near center of package. At end of 45 minutes the temperature of center of package was 120° F; about 5 minutes later, after being taken from oven it reached 124° F. Package opened on following day and all insects dead.

Thus we see that a direct exposure to a temperature of 180°F. for 4 minutes is fatal to all stages of the Mediterranean flour moth, but as soon as the insects are protected by even a very small amount of cereal the temperature or the time of exposure must be increased in order to kill all of the insects. The bran beetles are a little more resistant than the Mediterranean flour moth to the effects of high temperature.

In another set of experiments in which we used eggs, larvae and adults of a bran beetle (*Echocerus cornutus*) we found that a direct exposure of 1 minute at 181.4° F. killed all stages of the insect but when the box in which the beetles were held contained ⅛ inch of germea, an exposure of

4 minutes was necessary to be effective, and if there was ¼ of an inch of germea, it was necessary to expose the material for 6 minutes in order to kill all stages of the insect. If the box contained ½ of an inch of germea, 12 minutes were required to kill all stages.

If the temperature was reduced to 176°F, an exposure of 11 minutes was necessary to kill the insects in ¼ of an inch of germea, and 70 minutes were required to produce the same effect at a temperature of 122°F. Six minutes exposure was long enough to kill all of the insects in an open box with no germea.

These experiments seemed to show quite conclusively that the usual sterilization processes as practiced by at least some of the mills, were not killing all of the insects which might be found in the prepared cereals, so we set about trying to find some other more satisfactory method of accomplishing this purpose.

As it is always difficult to keep the steam pressure constant in any sterilizing apparatus, it seemed that it would be much better to use, if possible, a source of heat that could be made constant, and electric heat, of course, seemed to be the most available. After a series of experiments I found that a sheet of metal placed close to coils of electric wire could be heated to a high degree of temperature and this temperature maintained without any care on the part of the operator.

The apparatus that was finally devised for sterilizing such material as germea, corn meal, cream of wheat and other breakfast cereals, consists of three metal plates each with a heating element under it. These plates were placed one above the other in zigzag fashion so that the cereal running from the upper plate dropped on to the second plate and from the second on to the third plate. This provides for the material being turned over a time or two during its descent from the end of the first plate to the end of the third and prevents the material that is on the bottom at the beginning of the sterilizing process remaining in this position during the whole of the process.

The material should be poured on the plates slowly enough so that it will form a thin covering over the plates as it descends. We have found that the material passes over the plates more rapidly and there is less danger of its sticking to the plates if the whole apparatus is subject to some vibration.

We have found that it takes the material that is to be sterilized about 2 seconds to run over these hot plates and as the temperature of the surface of the plate is 300°F. a cereal passing over these three plates

reaches a temperature of from 100°F. to 190°F. depending upon the coarseness of the material. Such coarse material as flaked wheat and rolled oats would require a longer exposure, that is, it would have to pass over more plates before the sterilization would be effective, but such fine material as corn meal, germea and cereals of that type are thoroughly sterilized by this process, all of the stages of the insect including the eggs, being destroyed.

Careful tests made of the material before and after passing over these sterilizing plates shows that material with a moisture content of 10.63 comes from the sterilizer with a moisture content of from 9.23 to 10.10, or an average loss of 1.21%. This, of course, is inconsiderable.

As the material is to be packed soon after it comes from the sterilizer it will be best to screen it before it goes on to the first plate, the size of the openings of the screen depending upon the material to be sterilized. We find that a screen with a mesh .0328 inches in diameter removes all of the adult beetles and all but the smallest larvae from such materials as corn meal and germea. Anything that passes through this screen is so small that its presence can be detected only by the closest kind of examination. Unless the material has been standing for sometime after it was screened, there is very little chance of its being infested with these small larvae.

Summing up then we may say that the chief advantages of such an apparatus as this for sterilizing these cereals is its simplicity, its inexpensiveness, the constant temperature which is maintained without any attention from the operator, the small amount of moisture that is lost in the process, and the fact that the apparatus can be placed in the packing room close to the packing table so that the material can be packed in the containers immediately after sterilization. Experiments have shown that it is perfectly safe to pack the material immediately after it comes from the sterilizer.

Prof. Doane then exhibited a working model of the machine described in his paper.

COTTON BOLL WEEVIL AND THURBERIA BOLLWORM PROBLEM IN ARIZONA

By CHAS. T. VORHIES, *University of Arizona, Tucson, Ariz.*

ABSTRACT

The cotton growing valleys of southern Arizona, particularly those about Tucson are of great interest to southwestern entomologists because of the presence in the

near-by mountain ranges of certain potential cotton pests which occur on a native plant, the so-called wild cotton, *Thurberia thespesioides*. These insects are a native variety of the boll weevil, *Phytonomus grandis thurberiae* Pierce, and a noctuid moth, *Thurberiphaga diffusa* Barnes, the larva of which is a bollworm. The native weevil is shown to have habits distinct from the Mexican boll weevil. Both it and the bollworm are well adapted in their life histories to the normal late fruiting habit of the wild cotton. It is believed that either or both might, if proper opportunity were afforded become pests of domestic cotton.

A problem is created by the fact that in the district cultivated about Tucson the wild cotton, harboring both insects, grows quite close to areas on which domestic cotton may be grown. Incipient infestations of the weevil, but thus far none of bollworm, have already occurred in the past few years but have been stamped out. At present there is a controversy to be settled by the courts between the Arizona Commission of Agriculture and Horticulture and the cotton growers of this district regarding the maintenance of a non-cotton area near the natural habitat of Thurberia.

(Paper withdrawn for publication elsewhere.)

THE CITROPHILUS MEALYBUG, *PSEUDOCOCCUS GAHANI* GREEN, AS A MAJOR PEST OF CITRUS IN SOUTHERN CALIFORNIA

By H. M. ARMITAGE, *Entomologist, Los Angeles County Horticultural Commissioner's Office*

ABSTRACT

The citrophilus mealybug (*Pseudococcus gahani* Green) first found in the citrus orchards of Southern California at Uplands, San Bernardino County in 1913, is now established in all of the southern citrus producing counties with the exception of San Diego and Imperial. In Los Angeles, Orange, San Bernardino and Riverside Counties, it occurs over a rather large acreage. In Ventura and Santa Barbara Counties the infestations are new and as yet are confined to a limited acreage though none the less severe in degree of infestation. Due to adverse climatic conditions this species of mealybug has proven less serious in the interior counties as San Bernardino and Riverside and while the spread has continued the infestations have been exceedingly light since the date of the original outbreak. In the coast counties the spread has been rapid and the infestations as a whole very heavy. The citrophilus mealybug is particularly resistant to fumigation and has the usual resistance of this group of insects to sprays. Water under pressure during the peak of oviposition period in the spring is by far the most successful means of mechanical control. Natural enemies of which there are several native species present in the orchards are an important factor of control. The ladybird beetle, *Cryptolaemus montrouzieri* Muls., an introduced predator, is particularly effective. Eight county and Association insectaries in Southern California are producing and liberating monthly over half a million of these beetles, throughout the infested areas of Southern California. Where they are made available in quantity early in the year they are being used successfully as a control measure.

The mealybugs are not new pests to the citrus growers of California. The citrus mealybug (*Pseudococcus citri* Risso) has long been established

in the orchards of the coast counties where it has periodically caused considerable injury to this host. Baker's mealybug (*Pseudococcus maritimus* Ehrh.) and the Longtailed mealybug (*Pseudococcus longispinus* Targ.) have also been of common occurrence on citrus over the same area but can never be said to have been of any real economic importance. With the finding of a new species, (1) the Citrophilus mealybug (*Pseudococcus gahani* Green) at Uplands, San Bernardino County, in 1913, there was added to this group a member which has given evidence of being as serious a pest as the citrus mealybug, if not more so, and is now recognized as one of the major insect pests attacking citrus in Southern California.

The finding of this species at that time was particularly alarming to the citrus growers of the interior valleys as it had been previously supposed that this well-known pest of citrus in the coastal areas could not exist under their hot, dry climatic conditions. While the original outbreaks were rather severe in both San Bernardino and Riverside Counties, the two principal interior citrus producing counties in the Southern part of the State, recent developments have indicated that these climatic factors have a marked restricting influence in those areas, and while its spread has continued no serious infestations have been experienced since 1919. The coast areas however, seem as well adapted to this as to the other established species. Its spread, after once becoming established has been rapid with many serious outbreaks.

The Citrophilus mealybug is a rather omnivorous feeder, resembling *Pseudococcus citri* in this respect, and aside from citrus, attacks a wide range of host plants including many ornamentals as well as fruit trees. In fact, while records are rather indefinite on this subject, this pest was without doubt introduced into the citrus orchards of Southern California on ornamentals either from the vicinity of Los Angeles or from the San Francisco Bay region in both of which areas there is evidence of its occurrence prior to 1913.

General Descriptions

While this species might, from an external examination in the more immature stages be mistaken for the citrus mealybug, the adult female has a distinctive form and appearance which easily distinguishes it from the other species attacking citrus.

Green (3) has given the following very accurate and characteristic description: "adult female thickly coated with greyish-white mealy secretion, which is thinner in the folds of the segments and in the de-

pressed areas. These depressions are in four more or less confluent longitudinal series which are more marked on the posterior half of the body. The darker color of the insect showing through the mealy covering at these spots produces a distinct symetrical pattern." Ferris (4) also calls attention to the "longitudinal rows of impressed dots" as being "quite distinctive." It is this "distinct symmetrical pattern" together, as stated by Green, with the "claret colored liquid in round drops, two close to the head and two close to the tail end, exuded by the insect when irritated" which makes its determination in the field a rather simple matter in the adult stage.

Distribution and Means of Spread

While without doubt, wind and birds are important factors in the spread of this pest, particularly at the time of the peak hatch in the spring, when the minute young are moving freely in the trees in countless numbers, the more probable avenues of spread are through contacts made during cultural operations and the handling of the fruit in the field, particularly as community or association labor crews are in general use. The loose cottony egg masses as well as the freely moving individuals are easily carried on the clothing of orchard workers or on the cultural equipment and the migratory habit of the adult female in searching for a place for oviposition makes the field box an easy carrier from orchard to orchard.

Realizing the seriousness of these avenues of spread the Horticultural Officials in the infested counties have made every effort to control the movement of laborers and equipment between infested and clean orchards. Fumigation of all field boxes before leaving the packing house has been required. Laborers have been supplied with clean caps, jackets, coveralls, gloves and other equipment after leaving infested orchards and before entering clean ones. In many cases owners of infested orchards in comparatively free areas have been required to handle their fruit through packing houses in generally infested areas. In spite of all of these precautions however, the spread has been persistent, particularly in the coastal areas. It is entirely possible that in many cases establishment took place in unobservable quantities before its presence in the south was detected and attempts made to check its spread.

While Clausen (2) recorded less than ten acres at Uplands as being infested in 1915, Woglum (6) shows 600 acres infested in that same area in 1918, in 1922 this had increased to over 1000 acres and a spread was recorded into the adjacent counties of Riverside and Los Angeles. In

Riverside County 100 acres were recorded as infested and in Los Angeles County the infestations were scattered from the coast to the mountains through a belt including Long Beach, Los Angeles, Alhambra and Pasadena.

In the interior areas adverse climatic conditions have tended to delay the spread and to minimize the seriousness of infestations of the past few years. In the coast areas the equable climate has permitted the development of rapidly succeeding and overlapping generations and the spread has been alarmingly rapid with many serious outbreaks. The map of Southern California at the present time shows, aside from the previously mentioned areas, a general distribution over Orange County, about 3500 acres infested in Los Angeles County and heavy established infestations at Oxnard in Ventura County and at Carpenteria in Santa Barbara County. In fact it now occurs in all of the citrus producing counties of the southern part of the State with the exception of San Diego and Imperial. In Orange County the infested acreage has increased from a few scattered trees over 10 acres in 1921 to over 8,000 acres this season.

Though the distribution is wide spread, as yet less than 5% of the total citrus acreage of Southern California is actually infested. The location of this infested acreage, however, is such that it forms a potential source of spread to an exceedingly large adjacent acreage.

Seasonal History

In the interior valleys in which the original observations were made by both Clausen and Woglum as well as the writer (5) the seasonal history is confined to a heavy conspicuous generation in May and June preceeded by a light generation in February and March and with light succeeding and slightly overlapping generations during the summer months, increasing in intensity during the fall. Overwintering is carried out in the intermediate stages on citrus, under the buttons or in depressions in the fruit or between fruit clusters. Summer temperatures are without question responsible for a high mortality among the progeny of the heavy May and June generation which accounts for the light succeeding generations, with a slight increase as the weather moderates in the fall.

With the advent of this species into the coast areas, however, we have an entirely different situation. While in the main, the periods of occurrence of the succeeding generations are similar to those in the interior areas, the mild climatic conditions permit an increased develop-

ment with a marked overlapping of generations. Instead of a peak migration of adult females to the trunks of the trees—a characteristic of this species of mealybug—in May and June, we have a more or less continuous migration throughout the summer months. Starting with a rather well defined, though light generation in March, the increase in intensity is rapid and the generations are soon lost sight of due to overlapping. A peak is reached about June 1st, which is maintained throughout the season or until control is established.

Effect on the Host

In passing along the road there is little external evidence of a sometimes severe infestation of this species in an orchard with the exception of the presence of the usual "sooty mold" fungus developing in the exuded honey dew. A close examination of the infested trees, however, would show a heavy defoliation and killing of small wood in the interior of the trees. This condition late in the season might extend to the outside of the tree though such a condition is exceptional as control is usually secured before the injury extends that far.

Probably the most serious phase of an infestation of this species is the migration of the hatching young from the egg masses on the trunk in May and June to the stems of the young fruit which is just in the stage of "setting," exaggerating an already serious seasonal field condition known as "June drop." This condition is further exaggerated on Valencia orange trees due to the fact that the previous season's crop is still on the trees and the old fruit clusters hold adults and egg masses in close proximity to the newly setting fruit, insuring a higher percentage of young reaching it. In the case of severe infestations a large percentage of this new crop is lost before control can be established. Another avenue of loss in the case of Valencia oranges is through the collecting of individuals about the stems of mature fruit and through their feeding so weakening the stem that a heavy drop is caused.

Though the greater part of the present infested acreage is planted to oranges, the lemons and the pomelo have demonstrated their susceptibility to the attacks of this pest with a similar form of injury.

Relation to Ants

Ants, particularly the Argentine Ant (*Iridomyrmex humilis* Mayr) are recorded by Woglum as being present without exception in every case of severe infestation. This may have been true at the time his

observations were made, but recent developments have shown this species fully capable of reaching a stage of severity without the attendant protection of the ant. In Orange County less than 25% of the 8,000 infested acres is attended either by the Argentine Ant or by native species. In the Rivera section of Los Angeles County where at present the most severe infestations of that species in that area occur, less than one percent of the 1,000 infested acres is attended by ants.

This ability on their part to maintain themselves in the absence of ants, is not due to any lack of natural enemies from which the ant might protect them as this species is attacked by the same group of predators as the other citrus feeding species with one exception, the brown lacewings (*Sympherobius* spp.) and even these seem to be adapting themselves to this host as each season they are found more often feeding in the egg masses.

I do not intend to minimize in any way the need of controlling ants where ever they attend infestations of mealybug but merely to point out that at least this species is not entirely dependent on their protection for its existence.

Control

Mechanical Treatment. This species of mealybug has been reported by Clausen as being the most resistant to cyanide fumigation of any of the species attacking citrus, and it is a well known fact that none of the others can be successfully controlled in the field by this method. In the laboratory, using a gas tight box with a capacity of twenty-five cubic feet Clausen was able to secure a one-hundred per cent kill of all stages using a 70% schedule for one hour. The eggs succumbed to a 50% dosage and the adult females to a 60% dosage. The larvae and male pupae required 70%. More recent tests by Woglum in the treatment of infested cull oranges intended for byproduct purposes, when applied on a large scale, even in a practically air-tight room required 3 ounces for two hours or four ounces for one hour, to guarantee a 100% kill of all stages. It has been fully demonstrated in the field that a maximum dosage which may be administered in the field with safety to the tree is not sufficient to give a satisfactory commercial kill of any of the mealybugs, nor is this species any exception to the rule.

The citrophilus mealybug has the usual resistance of all other species to sprays due to the impervious coating of waxy secretion. Sprays containing an ingredient which will penetrate this wax usually are injurious to plant life and are not practical for commercial use.

A peculiar habit of a large percentage of the adult females of this species in descending to the trunk and main limbs of infested trees for the purpose of oviposition appears to offer an easy point of attack. Concentrating in heavy masses in the crevices of the trunk and under trap burlap bands, placed around the trunks of infested trees, at certain periods of the year, their removal at that time would seem to offer a very satisfactory means of control. This is partly true in the interior areas where as previously stated, adverse climatic conditions confine this mealybug to a single heavy generation or migration to the trunks in the spring, with very light succeeding generations. Under such conditions a trunk treatment might be applied economically. In the coast areas, however, the more equable climate permits a continuous development of overlapping generations which means a more or less continuous migration of adult females to the trunks, precluding an effective single treatment. Repeated treatments have been demonstrated to be of little value and the cost prohibitive. In the case of Valencia oranges where the previous year's crop is often held on the trees several months after the new crop has set, the clusters of old fruit serve as suitable places in which the adult females cluster for oviposition, further detracting from the value of trunk treatment. While oil emulsions have been used safely in these trunk treatments where conditions suggested the value of trunk treatment it has been fully demonstrated that water applied under pressure is fully as effective and does not materially interfere with the work of the many natural enemies which attack this pest.

Biological Control. While there are many native insect predators of the Citrophilus Mealybug present in the citrus orchards of Southern California, a practical application of this method of control is being carried out successfully, using an introduced coccinellid, *Cryptolaemus montrouzieri* Muls. Appreciating the fact that successful commercial control using this method is dependent on systematic quantity liberations of an effective enemy at a period in the year which will permit several months of continuous uninterrupted activity, laboratory work has been developed during the past few years which makes it possible to meet these conditions. The Cryptolaemus, introduced into California in the early '90s by Koebele of the United States Department of Agriculture has been selected for this work for several reasons. It had already demonstrated its ability to control the citrus mealybug (*Pseudococcus citri*) when introduced into an infested orchard and was determined as being equally effective against the present species; as a

predator it fed extensively in both the larval and adult stages; it has, so far as known, no enemies of its own in the form of secondaries established in California,—this cannot be said of the several very efficient native enemies which are heavily attacked by a number of secondaries and checked at the time they are approaching controlling numbers, in the field; and last but very important it lends itself readily to rearing in the laboratory.

Following methods worked out and using equipment developed by the California State Department of Agriculture, five county and four associations and privately owned insectaries are at the present time producing and liberating in the citrus orchards of Southern California over 500,000 of these beetles, monthly.

Liberations are being made on a community basis and cost of production is being met by owners of non-infested as well as those of infested groves on a basis of orchard protection. Systematic liberations are being made which calls for the placing of a reasonable colony of these beetles on each infested tree in the district as early in the season as field conditions will permit uninterrupted development. With a short life cycle averaging thirty to forty days and an average increase of two hundred per generation, control is assured within sixty to ninety days, this being a sufficient length of time in which to step themselves up to controlling numbers. Heavy infestations, due to the abundance of food material available, are most easily controlled. However, with a surplus of these predators created in an infested district, as a whole, the greater part of the infestations can and are being prevented from ever becoming serious. This method is the one which is being followed successfully and almost universally in California at the present time, both in the interior and in the coast areas.

Bibliography

1. Essig, E. O. The Mealybugs of California, Calif. Mo. Bul. V. 3, No. 3, page 110–111. 1914.
2. Clausen, Curtis P., Mealybugs of Citrus Trees, Univ. of Calif. Bul. 258, 1915.
3. Green, E. E. Observations on British Coccidae in 1914 with Descriptions of New Species. Ent. Mo. Mag., V. 51. 1915.
4. Ferris, Gordon Floyd. The California Species of Mealybugs, Stan. Univ., Ser. 1918.
5. Smith, Harry S., and Armitage, H. M. Biological Control of Mealybugs, Mo. Bul. Calif. State Dept. of Agri. V. 9, No. 4, 1920.
6. Woglum, R. S., and Borden, A. B. Control of the Citrophilus Mealybug, U.S. D.A. Bul. 1040 Bu. of Ento. 1922.

Prior to adjournment President Burgess gave an informal talk on various matters pertaining to the relationship between branches, sections and the parent association.

Friday Afternoon Session, June 28th, 1924

Chairman Smith called the meeting to order at 1:30 P. M. and called for the following papers:

LYGUS ELISUS ON COTTON IN THE PACIFIC REGION

By E. A. McGregor, *Bureau of Entomology, Lindsay, California*

(Withdrawn for Publication elsewhere)

PRELIMINARY REPORT ON THE USE OF CALCIUM CYANIDE AS A SOIL FUMIGANT FOR WIREWORMS

By Roy E. Campbell, *U. S. Bureau of Entomology, Alhambra, California*

Abstract

In a series of preliminary pot and field experiments calcium cyanide, used at the rate of from 130 to 400 pounds per acre, showed a decided toxicity to wireworms, Elaterid larvae, and indicated that about 200 pounds per acre if properly applied would kill 75 per cent, or more, of the worms.

Wireworms[1] have caused enormous damage to various crops on the Pacific coast for a number of years, particularly to beans, beets, and potatoes, but to many other crops as well. Many attempts have been made to control these pests, but none has proved satisfactory. One entomologist expressed his opinion that "wireworm control is a problem which we can leave for posterity to solve." With the constantly increasing damage from wireworms, however, it is becoming apparent that the discovery of some method of control can not wait on posterity.

It has long been known that hydrocyanic-acid gas derived from sodium or potassium cyanide would kill wireworms, but its use was impractical because of its high cost and its injury to plant life. The development of the low-grade and comparatively cheap calcium cyanide removes the first objection to the use of hydrocyanic-acid gas, and the use of the material when the ground is fallow, or prior to planting, eliminates the second objection.

In order to test the effect of Calcium cyanide on wireworms, a series of experiments was undertaken in the laboratory at Alhambra, Calif., in

[1]The species principally concerned are *Pheletes californicus* in Calif. and *P. occidentalis* in Washington.

June, 1923, 10-inch pots of soil being used, followed, in August, by field tests at Toppenish, Wash.[2]

In the pot experiments, various types of soil were used, as well as moist, dry, loose, and packed soil, and the relative locations of the cyanide and wireworms were also varied. A summary of all of the experiments show the following:[3]

TABLE I—SHOWING PERCENTAGE OF WIREWORMS KILLED BY DIFFERENT AMOUNTS OF CALCIUM CYANIDE DUST PER ACRE IN POT EXPERIMENTS AT ALHAMBRA, CALIFORNIA, IN 1923

Pounds per acre	Per cent killed			Number of experiment	Total number of worms used
	Maximum	Minimum	Average		
400	100	70	92	9	90
350	100	30	80	12	120
300	100	30	71	12	120
250	90	30	65	12	120
200	100	10	50	13	130
150	90	0	40	11	110
Control[4]	10	0	1	9	90

Although nearly a hundred experiments were performed, they were not considered sufficient to explain entirely the variations in results. An analysis of the experiments, however, suggests the following factors as having a bearing on the success or failure resulting in several cases:

(1) DEPTH OF CYANIDE. Following shallow applications, there remained in the pots a considerable percentage of live worms, nearly all of which, except in the case of light dosages, were several inches below the cyanide. It was therefore concluded from the rather meager evidence that the killing of few wireworms below the cyanide could be expected.

(2) MECHANICAL CONDITION OF THE SOIL. In experiments where the soil was left very loose, the killing in most cases was low, probably owing to the fact that the gas was allowed to escape too rapidly. Where the soil was packed hard, also, the killing was low, owing to the difficulty with which the gas penetrates soils in this condition.

(3) ACTIVITY OF THE WIREWORMS. As the experiments continued into the fall and the wireworms became less active, results showed

[2]The experiments at Toppenish were carried on under the writer's direction by Mr. John N. Stone.

[3]In these experiments calcium cyanide dust was used, while for field work the granular form was used.

[4]Of the 90 worms used in the controls, 86 were recovered, 85 alive and 1 dead. However, in none of the experiments were missing worms considered as having been killed. In computing the percentage of killing, only the dead worms actually recovered were used.

lower killing, even with the higher dosages. It may be that as the wireworms become less active the effect of the gas upon them decreases.

Results obtained at Toppenish, Wash., gave considerable promise, but difficulties were encountered owing to the lateness in the season, the hardness of the soil, and the increasing inactivity of the wireworms. Benefited by the experience gained in the fall, the experiments were begun at the first signs of wireworm activity in the spring, which was early in March. A special machine was designed by the American Cyanamid Company which could be attached to the beam of a plow and set to feed a definite amount of cyanide in the furrow just ahead of the soil which is being turned over. Disc and hoe drills also were used in the application of calcium cyanide. Soil examinations were made both in the plots and in other parts of the infested fields. The percentage of killing was ascertained by sifting several cubic feet of soil in each plot and counting the dead and live insects. A summary of the experiments up to May 5 shows the following results:[5]

TABLE II—SHOWING PERCENTAGE OF WIREWORMS KILLED BY DIFFERENT AMOUNTS OF GRANULAR CALCIUM CYANIDE, TOPPENISH, WASHINGTON

Pounds per acre	Per cent killed			Number of experiments	Total number of worms found
	Maximum	Minimum	Average		
350–500	100	100	100	4	35
280–300	100	71	93	6	141
225–250	100	77	89	5	58
180–200	100	21	73	11	335
130–150	81	16	49	8	154
Control	0	0	0	21	579

Here again it is at present impossible to explain the variations in results but a study of the experiments suggest several contributing factors, among which are the following:

(1) TEMPERATURE. During low temperatures the wireworms are inactive and probably not so greatly affected by the gas as when active.

(2) MOISTURE. In several of the experiments where poor results were obtained the soil was wet. It is well known that moisture will absorb hydrocyanic-acid gas and that when too much moisture is present the calcium cyanide breaks down, forming ammonia and thus lessening the amount of hydrocyanic-acid gas given off. Probably this is what happened in some of these experiments.

(3) METHOD OF APPLICATION. In most cases better results were

[5]The type of soil at Toppenish is volcanic ash loam, and was practically uniform in all plots, varying only in its mechanical condition.

obtained with the drill, which placed the cyanide in the soil in rows 6 or 8 inches apart, than with the plow applicator, which placed the cyanide in rows 14 to 16 inches apart.[6]

(4) TEXTURE OF SOIL. Too loose or too compact a soil also seemed to be the cause of poor results.

(5) DEPTH OF APPLICATION. This appears to be very important, for equally poor results were obtained when the cyanide was placed too near the surface and when it was placed too deep. The depth at which the majority of the wireworms occur seems to determine the proper depth for applying the cyanide. This depth appears to vary throughout the season but the habits of the worms have not been sufficiently studied so that it can be predicted with certainty. In most of the experiments, however, the best results were obtained when the cyanide was applied from 4 to 6 inches deep.

The experiments so far have not determined whether it is best to apply the material early in the season, or as late as possible, just prior to planting, but indications are that late spring will be the best time. In early spring the worms are not only more or less inactive, but are fairly deep in the soil. When the soil warms up they become quite active and feed near the surface, but with the advent of hot summer weather, they go deeper in the soil again. Screening of a number of one-foot cross sections of soil in the last of February showed that 46 per cent of the worms were in the upper 4 inches, 40 per cent from 4 to 6 inches deep and 14 per cent from 6 to 8 inches. On May 5, however, 73 per cent of the worms were in the upper 3 inches and 90 per cent in the upper 4 inches.

During cold weather worms turned up by the plow show very little activity, remaining at the surface, often exposed for some time, but in warmer weather such worms rapidly work back into the soil. In the Yakima Valley early applications also killed many adults which had not as yet emerged from the soil.

To determine how long the cyanide remained in the soil, definite applications followed by chemical analyses were made, with results as follows: No cyanide could be detected in a wet soil[7] after 2 days when 150 pounds per acre had been applied and none after 4 days following an application of 500 pounds to the acre. In a dry soil[7] a faint trace of cyanide could be detected on the fourth day after using 150 pounds per

[6]The use of the applicator on 8 or 10-inch bottom plows, or with a spreading device, would remove this difficulty.

[7]The wet soil had more and the dry soil less than the optimum amount of moisture for cultivation or planting.

acre, and on the tenth day when 500 pounds per acre was used. The quantity toward the end of the period was extremely small in each case. These data indicate that the cyanide remains in the soil for only a short time, and that it will be perfectly safe to do the planting within a week or 10 days after application. These results have been confirmed by field experiments. Seed potatoes planted immediately or the next day after a calcium cyanide application were all injured, but when planted a week or more after the application they showed no effect from the cyanide.

The application of calcium cyanide to soil in which plants, such as potatoes, bulbs, and young seedling trees, were growing, demonstrated that when it was placed close enough to the plants or used in quantities sufficient to get a good killing of wireworms, injury to the roots or tubers resulted.

On only one experimental plot are the plants sufficiently advanced in growth at this writing to show the effect of the treatment on the crop. A treated potato plot on badly infested soil shows a decidedly better stand and growth than the untreated adjoining areas. This not only indicates that the wireworms were controlled, but also that the calcium cyanide did not injuriously affect the soil for subsequent plant growth. Practically all plots have been planted to some crop, and examinations will be made during growth and at harvest to determine how effective the treatment has been in increasing the quantity or improving quality.

The experiments so far have been intended primarily to determine whether calcium cyanide will kill a satisfactory proportion of the wireworms when applied in moderate amounts. They indicate that 200 pounds per acre if properly applied will kill 75 per cent, or more, of the worms at a cost of about $30 per acre. It should be borne in mind that the benefit of one treatment will extend over two or three years at least,[8] owing to the fact that it requires about three years for these wireworms to reach maturity and a single brood may cause injury over this period.

Experiments are now under way to discover means of reducing the amount of cyanide required per acre and thereby the cost of treatment. It is a well-known fact that wireworms collect in the rows of beans or other crops; therefore, if advantage is taken of this habit by drilling in split beans, rice bran, or other attractants, to induce the wireworms to concentrate in rows 2 or 3 feet apart, and subsequently treating these rows with a fairly heavy application of cyanide, a better killing may be

[8] In addition to controlling the wireworms, there is some evidence that the use of calcium cyanide increases the nitrogen content of the soil.

obtained with less material per acre. Improvements in methods of application are also under way, as well as experiments to ascertain the proper depth of application, distance between treated rows, best time to apply the cyanide, etc.

The calcium cyanide used in the field experiments was the granular form, which is the ordinary flakes ground to about the fineness of coarsely ground coffee and the finer particles sifted out and discarded. This material feeds readily from grain and small seed drills, is more conveniently handled and applied and appears to give better results than the finely ground dust.

CONTROL OF THE APPLE BLISTER MITE IN THE NORTHWEST

By LEROY CHILDS, *Hood River, Oregon*

(Withdrawn for publication elsewhere)

CITRUS SPRAYING IN TULARE COUNTY

By A. F. KIRKPATRICK, *Lindsay, California*

(Paper not received for publication.)

NOTES ON AN OUTBREAK OF CUTWORMS

By S. J. SNOW, *U. S. Bureau of Entomology, Salt Lake City, Utah*

(Paper not received.)

The following papers were read by title:

SPRAY STIMULATION

By FRANK B. HERBERT, *Assistant Entomologist, Balfour Guthrie & Co.*

ABSTRACT

Stimulation to deciduous fruit trees has been noted from a number of different sprays, but the greatest amount has occurred after using the heavy types of Miscible oils.

Stimulation is due partly to the heavy oil base and partly to the emulsifiers in them.

The condition of the tree and soil and time of spraying are factors in the amount of stimulation to be obtained from the oil spray. The spray must be applied between December 15th and February 1st to be certain of it.

Although there may be some disadvantages, the advantages are many such as: 1. The early bloom makes the fruit set early, thereby coming ahead of the emergence of

the Thrips, insuring more and cleaner fruit. 2. Causes early formation of large green leaves, covering small fruit, protecting it from sunburn and frost. 3. The fruit gains much of its growth before natural moisture evaporates. 4. Causes tree to function properly, producing larger crops and larger fruit, and 5. Fruit will be harvested earlier, insuring better prices.

Examples cited and photographs.

Stimulation to fruit and foliage has been noted from time to time from the application of dormant sprays. Lime Sulphur Solution and Bordeaux Mixture have been mentioned by growers and investigators occasionally but the oil sprays are mainly responsible for this stimulation.

Lime Sulfur Solution will occasionally show a slight stimulation to prunes or pears, but has a decidedly opposite effect upon apricots if applied late in the spring, causing the fruit to ripen late and both fruit and foliage to be small and yellow. Apricot trees are very susceptible to sulphur poisoning in all forms, with one exception. The writer has never seen Barium Sulphur (BTS) retard the growth of apricots or any other variety of fruit. In fact, it seems to be a very fair stimulant.

Bordeaux Mixture applied to deciduous fruits, particularly in the fall, will often have a noticeable effect in hastening the bloom in the spring.

Oil Sprays

Oils very often cause a more distinct hastening of the bloom and ripening of the fruit than any other spray. This has been noted with the heavier types of emulsions and miscible oils and very seldom with the lighter types made from kerosene or distillates. These lighter oils gave some stimulation in the spring of 1924, which was a very abnormal year with a very light rainfall. The reason that the lighter types do not generally cause stimulation is due in the main to the fact that they evaporate too quickly and are not on the tree long enough to give any lasting benefits.

With the heavy types of oil this effect has been very pronounced, more so with the true Miscible oils than with the ordinary emulsions.

By the term Miscible oils is meant an oil containing liquid emulsifiers, particularly Cresylic Acid, the finished product resembling an oil in appearance. Some paste type emulsions have been called Miscible oils or Miscible Type oils simply because they turn white like miscible oils when added to water, but this is apt to cause some confusion.

The stimulation from the oils is partly due to the emulsifiers, also, as a heavy oil emulsified with a mineral salt or colloidal material does not

usually give the same stimulation that one emulsified as a Miscible oil does. In fact, certain makes of Miscible oil will show this more than others.

Balfour Guthrie & Company manufacture a full line of Miscible oils and under the leadership of their entomologist, Paul R. Jones, have made an exhaustive study of the proper types of oil and emulsifiers for the best stimulation and Scale kill, and yet retain a high safety factor. Probably no other concern has the knowledge of the manufacture and field use of oil sprays that this company has. One reason for this is that they have been manufacturing oil sprays for some twelve or thirteen years and Mr. Jones, and the writer as well, had a number of years experience previous to this while working for the United States Government. There are certain ingredients in their Miscible oils which are not found in any other brand, at least not in the same proportions.

Conditions Necessary

Certain conditions must exist in the orchard before this stimulation will take place.

The amount of moisture in the soil is one of the most important factors, therefore, the spraying should not be done until several inches of rain have fallen within a few weeks previous to the application. There must be plenty of plant food available in the soil.

Naturally, one can not expect to obtain a crop by spraying only. The grower must give the orchard proper pruning, irrigation and cultivation together with the spraying for the best results.

In the California coast counties the proper amount of moisture will generally be present by early December. However, in 1923 the work did not start until the latter part of December, due to lack of moisture. Therefore, the work should be done from early December to the last of January. Although the stimulation has taken place at various times from materials applied throughout February, still one can not count on its happening from so late an application. Often too late an application will retard blossoming.

Effect of Stimulation

The effect of the stimulation is to cause a vigorous early bloom, varying from five to twenty days earlier than normal, according to the dosage, time, weather and condition of the orchard.

Prune growers in the Santa Clara Valley have found that a full bloom appearing before March 20th insures one of a good crop; appear-

ing from March 20th to April 1st presages a fair crop and a bloom after the first part of April means a poor crop. On the whole this seems to hold good.

Disadvantages

Some growers argue that the sprays will hasten the bloom so much that it will make them more liable to injury from frost. This has not been noted in the Santa Clara Valley by the writer, but this might happen once in a great while with some varieties of fruit in certain localities. If one does not want to obtain the early bloom he can spray rather late and clean up his trees from pests with practically no stimulation ordinarily.

Others argue that there will be a reaction to excessive stimulation, yet nothing of the sort has been noted to date on orchards that have had an annual treatment for four and five years in succession. In comparison, there are non-poisonous stimulants, such as spirits of ammonia, administered to human beings with no apparent detrimental reaction. so that the same should apply to plants as well.

Excessive dosages of spray material may cause a retardation instead of a stimulation when applied under some conditions. This is to be expected as it is true of practically any stimulant when applied too freely.

Advantages

Some growers are spraying with an oil spray every season in order to obtain the benefits to be derived therefrom. This applies particularly to prune, apricot, and cherry growers.

1. The early bloom causes the fruit to set before the Thrips appear, thereby giving more and cleaner fruit in sections where this insect is a problem.
2. The spray causes the foliage to grow very fast, covering the small fruit and protecting it from sunburn and frost.
3. Moreover, the fruit attains much of its growth before the natural moisture has evaporated from the ground.
4. The early vigorous bloom produces an earlier harvest, thereby reaching the market in time for better prices.
5. It will cause larger crops of larger fruit. This is probably due partly to having the tree free from pests, thereby being able to function properly; partly to obtaining its growth early before the hot weather sets in to retard it; partly to the large dark green leaves which the tree obtains early; besides the direct effect of the stimulation.

1. Noah G. Rogers prune orchard, Los Gatos, California. The trees on the left sprayed with Dormant Soluble Oil, bloomed nearly three weeks earlier than those unsprayed on the right. There is a large difference in the crop as may be seen from the photo below.

2. Noah G. Rogers prunes. Los Gatos, California. Sprayed with Dormant Soluble Oil on right, unsprayed on left.
Photos by Frank B. Herbert.

Examples

A good example of the latter is the Van Dorsten and Lester orchard near San Jose, California. They doubled the number of prunes per tree on the area sprayed in the spring of 1923 over the part of the orchard not sprayed. The prunes on the sprayed area ran ten to fifteen points larger, too, which would not be expected normally, for a tree with a larger crop usually produces smaller fruit than one with a small crop.

One advantage of the early harvest has been noted by the Losse Brothers on their 150 acre apricot orchard near Sunnyvale, Calif. They have found by spraying half the orchard with heavy miscible oil that they can nearly complete harvesting their fruit on this half before the other is ready, thus greatly reducing their labor problem which is often a real factor with so large a ranch.

Dan Regan, on the Blauer Ranch near Saratoga, California, has sprayed his apricot trees with heavy miscible oil for four years in succession now and each year he has produced an early crop of large, clean fruit, which the canneries are anxious to obtain for they can dispose of this fruit before the bulk of the fruit throughout the Valley is ready to can.

E. B. Stone has been using heavy miscible oil on his prune orchard near Campbell, California, for five years in succession now and he feels that the spray has "put the dollars on his trees" every year. These last two cases certainly show that the continual use of oil does not injure the tree or crop in any way.

Another example of a large crop increase should be noted in the Rhoades Ranch near Morgan Hill, California. On the place are fifty-five acres of nine and ten year old prune trees which heretofore have never produced more than twenty-six tons of green fruit. This season, after its first spraying, it is estimated that the crop will consist of at least two hundred and twenty tons green, or approximately ten times greater than what it has ever produced before. Some may say this is because the trees are now at the right age to bear and it is true that they are. However, every tree on the ranch, from three to ten years old, that was sprayed, now has a heavy crop of large fruit, showing that age has very little to do with it.

A. N. Kellner, Edenvale, sprayed his prune orchard in early 1923 and had a crop which averaged nine green tons per acre, while the average through the Valley was but one ton per acre. He sprayed part of the orchard again in 1924 and has a much larger crop on the part sprayed as compared with the unsprayed.

There might be added to the above names a long list of growers in the Santa Clara Valley who have increased their crops by spraying with heavy miscible oil, but the above should be sufficient to convince the most skeptical.

LIFE HISTORY AND BIOLOGY OF *ECHOCERUS CORNUTUS* (FAB.)

By DAVID SHEPHERD, *Stanford University*

ABSTRACT

Echocerus cornutus, a cosmopolitan bran beetle is found injuring cereal products. A description is given of the various stages of the insect together with notes on life history and food habits.

Results of experiments to test the attraction of water for these insects and the effect of air-tight sealing on the life of the insect, and the effect of humidity on the rate of development, are given.

Echocerus cornutus is cosmopolitan in its distribution but according to available data is injurious to cereal products, in the United States, only in the coast and bay regions of California. In spite of its economic importance, the literature dealing with this Tenebrionid has done little in furnishing information as to its life history or general habits and for that reason the following condensed account of the study and observations of this beetle is given.

THE EGG. The egg is oval elliptical in longitudinal section and its size when coated depends upon the size of the particles of the material in which it is deposited, the actual measurements showing it to vary from .48 mm. to .51 mm. in width and from .85 mm. to .93 mm. in length.

When first deposited the egg is of a pure white glistening color, covered with a viscid substance showing a series of fine lines circling it radially, this being its complete sculpturing. After the egg has been deposited for some time it changes in color from the pure white to a straw color.

The eggs are ordinarily found among the particles of material in which the beetles live. In some instances they have been found adhering to the side of the carton or container in which the material has been placed.

THE LARVA IN ITS LAST INSTAR. The larva in its last instar is elongate, subcylindrical, convex dorsally and slightly convex ventrally. In color it is yellowish, the ventral surface being lighter in color than the dorsal. The head and the posterior portion of the larva are darker in

color than the rest of the body. The head is a pronounced brown, the edges of the mandibles are black and the bases of the mandibles are slightly brown. The claws on the legs are slightly brown and the spines show some little pigmentation.

The head is subquadrate, quite convex and bears six stout hairs on the lateral dorsal surface. The eyes appear as two almost spherical spots on the anterior lateral part. The antennae are pale yellow in color, showing a basal segment, a large second segment followed by a smaller segment which in turn bears a bristle.

The mouth-parts are directed ventrally. The labrum is large, the basal joint trapeziform and the terminal joint rounded bearing several small hairs on the margin. The mandibles are large, heavy and visible from above. The labium does not cover the mandibles, the labial palpi are cylindrical in form and two-jointed. The maxillae are longer than the labrum, the maxillary palpi are three-jointed, having a rather short basal joint, a second joint longer than the basal joint and a third joint papilliform. The submentum is larger than the mentum.

The thoracic legs are rather stout, the first pair being longer than the second and third pairs. On each leg there is borne a terminal hook, the tarsus bearing two short spines on the inner distal margin, the tibia bearing three marginal spines and the femur bearing four spines.

Each abdominal segment bears six spines. The caudal segment, which is scutelliform, is slightly convex dorsally and convex ventrally, bears four spines on its terminal dorsal margin and six spines on either lateral margin.

Pupa. The pupa ordinarily measures 3.6 mm., in length with a head measurement (width) of 1.35 mm. It is slightly arcuate dorsally, flattened to slightly concave ventrally. In color it is entirely white when emerging with the exception of the pigmentation of the eyes and mandibles which increases rapidly. The head is pressed into the prosternum, the pronotum is very broad and even with the head, making the head invisible from above. The mesonotum is narrow and scutelliform, the metanotum saggitiform and about as broad at the anterior margin as the mesonotum.

Seven abdominal segments are visible. The caudal segment bears a pair of posteriorly directed spines near the posterior margin dorsally, and a pair of median anal lobes ventrally. The first six abdominal segments bear lateral lobes each supplied with two setae.

The head, legs and antennae of the pupa are free, the antennae passing behind the first and second pairs of legs and over the base of the wing

pads. The elytra are folded ventrally but not over the legs. The lateral hairs remain on the abdominal segments.

The sexes of *Echocerus cornutus* are easily distinguished in the pupal stage, the female possessing a pair of appendages on the terminal abdominal segment while the male presents only indistinct elevations in this region.

THE ADULT. The adult is shining reddish brown in color and has a length of about one-eighth of an inch. The head is restricted behind the eyes so as to be drawn into to the prothorax nearly to the eyes, is narrower than the thorax and is densely punctured.

The eyes are dark, deeply emarginated and extend underneath the head. The antennae are clavate and sparsely covered with hairs. The mandibles of the female are short and of the usual type but the mandibles of the males are very conspicuous in that they are broad and expanded at the base but as they extend forward they taper to a point, being curved distally. Another marked difference between the male and the female is the presence of two prominent tubercles in the center of the head of the male.

The prothorax is rectangular and margined by a deep groove, the anterior angles being slightly rounded and the posterior angles sharply curved, wider than long, flattened dorsally and densely punctured with round pits.

The middle coxa is without a trochanter, the hind coxa separated, the tarsi pubescent beneath with the last joint much elongated.

Each wing cover has six narrow longitudinal depressions with ridges in between. In each depression is a row of shining black punctures, the entire under surface of the elytra is also punctured. The posterior portion of the abdomen under the elytra is black.

LIFE HISTORY. The eggs of the beetle were laid singly and within twelve hours after copulation. These eggs hatch under a temperature of 76°F. in ten days. The larva in emerging from the egg appears to cut its way from the egg case and emerges through a round opening in the end. Preparatory to its first molt, it is inactive and the body seems to contract giving the whole a somewhat unnatural aspect. The larval skin splits dorsally for its entire length and is usually left away from the meal. As soon as the larva passes thru its first molt it commences feeding again. If feeding on germea, the length of the second instar is six days, the third instar six days, fourth instar four days, fifth instar nine days, sixth instar seven days, eighth instar five days, the ninth and last

instar lasts for a period of fourteen days, two of which are spent in an inactive condition which I choose to call a prepupal stage.

Food Habits. I have found, during my observations, *Echocerus cornutus* feeding in flour, corn meal, germea, dog biscuits, corn, pancake flour, yeast cakes, bran and farina. By means of tests it has been demonstrated that these beetles show a preference for flaky material and this choice may be linked up with the tactile responses of the beetle.

Damage to Foodstuffs. The chief damages to foodstuffs occasioned by the presence of *Echocerus cornutus*, are the presence of either living or dead insects, either in larval or adult form; the presence of cast skins; the loss of material eaten during growth and the presence of accumulated dust and frass.

Attraction by Water and Moistened Materials. In some tests to determine whether or not these beetles were attracted by water I found that even in the face of a mechanical difficulty they would make an effort to get to the water. So pronounced was this attraction that my interest was aroused in determining whether or not moistened material would be as attractive as the water. Accordingly I mixed some water, with meal and in comparing the infestation of the moistened material with that of the dry there was shown a very decided preference for the former. Believing that some use could be made of this preference in the mixing of bait and using arsenicals as one of the ingredients, some poisoned material was prepared by the use of Paris green and arsenious acid The result of experimentation with 100 beetles went to show that there was a decided preference for the moistened material. The material poisoned with Paris green acted somewhat as a repellent, more dead and living beetles being found in the meal poisoned with the arsenious acid. At the end of sixty-five hours but fifteen live beetles remained.

Effect of Air-Tight Sealing on Echocerus cornutus. Even today the opinion is rather general that "bran beetles" or "Weevils" can live almost wholly independently of ventilation and that a non-ventilated atmosphere, of a somewhat optimum temperature and amount of water vapor provides the most favorable condition for the reproduction of the insects. In the light of experiments performed, such ideas are entirely erroneous. Adult beetles, *Echocerus cornutus*, succumbed to the lethal effects of air-tight sealing in the short period of five days and the larvae of the same beetle succumbed, under the same conditions, in from five to ten days.

While conducting certain tests notice was taken of the mortality suffered by these beetles when confined in open vessels containing food,

and apparently living under favorable conditions as regards humidity and temperature. To supply a possible explanation for the same a rather long line of tests was conducted by supplying food materials in varying amounts to open mouth bottles and introducing into this food a definite number of beetles; a careful count to be made of the mortality rate at different intervals of time. As a result of these tests it was shown: that apparently the greater the air space, the more pronounced the increase in the rate of mortality. As a check upon these tests two other experiments were determined upon: one by supplying mechanical means for making it possible for the beetles to maintain a position near the opening of the mouth of a bottle containing little food and the other, by means of an air suction pump to supply a constant change of atmosphere to a bottle containing a small amount of food. These and the other tests mentioned indicated that some factor or factors entered to bring about a lethal effect upon the adults of these beetles, and these were more or less dependent upon the amount of atmospheric space above the meal and below the opening of the mouth of the bottle, unless a constant change of atmosphere was supplied in which case the rate of mortality was lowered.

A number of factors to account for the above might be suggested,—carbon dioxide, a gas heavier than atmosphere and a gas given off during respiration of the beetles or grain, a diminished oxygen supply, a gas or gases as yet unidentified, are within the limits of possible causes.

Following the suggestion that CO_2 may be the toxic substance and possibly its source, the product of the meal in which the beetles were kept, this meal was heated to 115°C. for one hour to make ineffective the enzymes for CO_2 production, it was found however, that the rate of mortality of beetles living in that material was higher than that of beetles living in unheated material, so if CO_2 is the toxic substance it must come as a product of the metabolism of the beetles.

Effect of Humidity on the Rate of Development of Echocerus cornutus. Headlee, Parker and others have shown that humidity has an effect upon the rate of metabolism of insects. In order to determine in a general way, the effect of varying degrees of humidity on *Echocerus cornutus* I designed the following experiment. One hundred and twenty-five adult beetles, and one hundred larvae in last instars, were placed in open cartons containing germea and then placed under bell jars under varied moisture conditions, the humidity of the bell jars being controlled by drawing air thru a calcium chloride dryer, which gave it a humidity of less than 1% and then passing this thru concentrated solu-

tions of calcium chloride giving the atmosphere a humidity of approximately 25%; copper nitrate approximately 45%, sodium chloride 75% and thru distilled water approximately 100%. Atmosphere of room humidity was introduced into one of the bell jars and atmosphere drawn thru a calcium chloride dryer was introduced directly into another bell jar. The atmosphere was taken from the bell jar having the selected percentum of atmospheric moisture to a constantly functioning suck pump.

Using the following as an index as to the effect of the different percentages of moisture; the number of beetles surviving; the number of living and dead larvae; the increase in the number of larvae in first instars, I reached the following conclusions: extending over a period of fifty days in a mean temperature of 65°F. adult beetles and larvae in the last instars seem to be but slightly affected by an atmospheric humidity ranging from approximately 1% to 100%. As the humidity increases up to 75% the number of dead beetles in the jars increase; from the fact that I found as many dead beetles in the jar having 100% as in the jar having 45% this data does not seem to be conclusive and further experimentation is necessary to test out this discrepancy. A very marked increase in the number of larvae of the first instars accompanies an increase in humidity, the actual numbers in increase being from 58 in atmosphere of 1% humidity to 412 in a humidity of approximately 100%. The optimum humidity for young larvae of *Echocerus cornutus* is approximately 100% but with this humidity, in the course of thirty days, a fungus appears which no doubt would, in a very short time be destructive to all beetles. In the light of this then it is quite possible that the most favorable condition for the development of this beetle would be in an atmosphere of a humidity of somewhere between 75% and 85%. In this experiment no account was taken of changes of temperature and light as I considered that for practical purposes perfect control of these factors was unnecessary.

It is unfortunate that the test could not be extended over a longer period of time,—I intend, however, at a very early date, to repeat this test, extending it over a much longer period of time.

Methods of Control. The chief means of control of *Echocerus cornutus* are the use, in Germany, of *Bacillus-thuringensis*; in England, hermetical sealing; in Canada, of chloropicrin, and in the United States and elsewhere, the elimination of breeding places, fumigation with carbon bisulphide and hydrocyanic acid gas and the heating of mills to a temperature of 120°–130°F. for a period of twelve hours.

SIMPLE METHODS OF REARING WIREWORMS (ELATERIDAE)

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ABSTRACT

It is the purpose of this paper to record a few successful and simple methods of rearing one of the most difficult groups of insects with which the economic entomologist has to deal, namely wireworms of the family Elateridae. The writer's studies and experiences have been confined mostly to two species, *Ludius noxius* Hyslop and *Pheletes occidentalis* Candeze of Washington State, but since these two species exist under a great variety of conditions from very dry to very wet, it is felt that the suggestions regarding methods and rearing here given can be adapted for other species in other sections.

In rearing subterranean larvae, such as wireworms it is almost a necessity to have some sort of an underground or cellar laboratory. Of course an underground chamber fitted with extensive temperature and humidity control apparatus would be ideal, where the expense could be afforded at some permanent research laboratory. But for all practical and general purposes a house or outside underground root cellar will answer very well. The latter is ideal in situations where there is good drainage and may be constructed with side walls of boards, a dirt floor, double doors, and a roof covered with sods. If shelves and a table with a light are installed, the different stages of the wireworms can be handled without fear of injuring them from lack of humidity or through extremes of temperature. Humidity and temperature usually remain about the same as are normally found from four to ten inches deep in the soil, varying about the same or very little from day to day. In the case of a laboratory situated in a house cellar made of cement, it would probably take some practice to maintain the proper amount of humidity and temperature. A separate small room in the north corner of a large cellar would seem to offer the best solution.

Adult elateridae can usually be procured in the fields by sweeping in the early spring, especially along the fence rows and ditch banks. It usually takes several consecutive warm days with temperature over 70 degrees F. to bring the adults from their winter cells, but when the weather once becomes permanently warm the adults will emerge and fly actively on sunny calm days for a week or two, after which the emergence is over till another year.

The obscure habits of the female adult elaterid and her apparent inaptitude to fly and expose herself as freely as the male, makes the procuring of sufficient females for rearing purposes difficult. In order to make sure of a supply of female adults, it was found necessary to rear

them from larvae. This should be done the previous spring by collecting as many full grown larvae as possible and confining them in soil cages. A simple and very effective soil cage for rearing any stage of the larvae can be made out of galvanized sheet iron, of guages ranging from 20 to 30. These are best made in the form a cylinder, by rolling two pieces of iron of the same size to a half circle and joining them together with baling wire, a fold being provided on one vertical edge of each half to receive the straight edge of the opposite half snugly. These cylinders without top or bottom can be made in any desired diameter and depth, but two pieces of galvanized iron 23 x 18 inches in the flat, when rolled and one edge of each folded over and back once using up 1½ inches of iron, will make when joined together, a cylinder about 12 inches in diameter and 18 inches deep. This is set into the ground at a depth of at least 15 inches and filled with soil. The soil within the cylinder should be tamped as hard as normal soil in field, or preferably the cages should be placed in the ground during the previous fall, in order that the winter rains and snows may settle the soil normally. When the soil is left too loose, the wireworms are likely to burrow deeply and possibly escape from under the lower end of the cylinder. The described size of cylinder accommodates ten or more larvae easily and is not too heavy for one man to lift from the ground and examine. When ready for examination this cylinder should be dug and laid horizontally on a canvas, in which position the upper half can be removed and the soil examined carefully by screening or otherwise.

Full grown larvae if placed in these cylinders before June first will pupate normally and thus with a series of cylinders the pupal stage or period can be determined accurately. If adults alone are desired it is best to leave the cylinders undisturbed until the following spring, when they can be removed before regular emergence date and adults recovered in perfect condition. Adults when taken from the soil in the fall and kept over winter in small tins usually have a high mortality from molds and bacteria.

Adults procured for rearing should be kept separate according to sexes till ready for mating. Sexes of the economic species of Elateridae can usually be determined by the more robust form of the female and her shorter antennae with joints slightly stouter. The male is usually slender, with antennae reaching nearly to the base of the thorax and joints flattened laterally.

Mating of adults is best done on warm sunny days, inside or out of the wind. Containers deep enough so that the beetles cannot fly or climb

out easily can be used, and the adults placed in these on a little damp soil, either in pairs or in numbers. As soon as a pair of adults are noticed in copulation, they can be removed in situ and placed in salve tins.

For all rearing purposes with wireworms the ordinary salve tin, either with plain or paper label lids, of the two ounce size seem to fulfill all the requirements. Smaller sizes will not contain enough soil and dry out too easily, while larger sizes are unnecessary, unless one wishes them for field collecting.

In order to save time in picking eggs from the soil of the salve tins after oviposition, the soil should be sifted through fine brass screen of mesh sufficiently small to retain the eggs of the species under study. A common milk screen of 40 mesh to the inch is about right for most of our economic species. Small deep round cake pans about 10 inches in diameter with false bottoms can be purchased cheaply and the screen easily soldered to the bottom. Soil should be as damp as will sift through this screen. After a female has oviposited a lot of eggs in this tin of fine soil, the contents can be sifted again and all the eggs retained free from soil.

Eggs can easily be counted by placing them in a shallow coffee can cover painted a dull black and using a tally counter operated by foot power. As soon as counted, the eggs should be placed on sterile watch glasses, either with or without filter paper, and the watch glasses placed in sterile petri dishes containing a little water. This provides a moist chamber without bringing an excess of moisture in contact with the eggs and when kept in a humid cellar will hatch the eggs normally. Eggs can also be left in the fine soil in salve tins until all the larvae have emerged, when it will be easy to sift out the newly hatched larvae. Care is necessary in the egg stage to prevent molds from entering the dishes and killing the eggs. Since the mold often enters the dishes with a slight amount of soil that sticks to the eggs, it is almost impossible to prevent some of the eggs from being lost in this way. The ordinary china marking grease pencils are very useful in marking on the glass of the dishes and also for marking the salve tins.

When the larvae begin to emerge from the eggs they should be removed daily from the dishes to finely sifted soil in the salve tins again, with their preferred food. Sprouting wheat with its fine rootlets serves well for those species destructive to grains. Sliced potatoes or sugar beets can be used for other species. The soil in these tins should be changed as often as necessary to renew the food and prevent them from drying out. By using the finely sifted soil again, the larvae can easily be

found by resifting. Several ways of rearing the tiny larvae have been tried in order to obtain the molted skins, but no very satisfactory method has been found. The best method seems to be in placing the larvae on sliced roots in petri dishes between layers of dark colored blotting paper, but it is very hard to keep the dishes clean and at the right degree of moisture.

After the larvae attain a size of 8 to 10 millimeters they can be placed in outdoor cylinders. Cylinders prepared for the reception of these small larvae should be filled with soil sifted through a 20 mesh screen to keep out strays and still be able to retain the larvae under observation when necessary to resift.

Adults after mating can also be introduced directly to the outdoor cylinders, by using a screen top of ordinary window screen. The screen should be cut to fit snugly within the cylinder and be as high as necessary to allow for plant growth. This screen cylinder top can be sewed with copper wire and if the selvage is allowed to come at the top, be made beetle tight by bending inwards in three places and sewing the selvage together where it meets. One or more mated female adults introduced in one of these cylinders will burrow down and deposit their eggs normally, so that on subsequent examination the depth of oviposition can be determined. These screen tops can also be used to determine spring emergence dates of adults.

For outdoor life history and control work with wireworms where it is desired to eliminate as many unknown factors as possible, a larger cage can be used. This cage can best be made in the form of a rectangular box without a bottom, 10 feet long by 4 feet 4 inches wide, containing approximately one thousandth of an acre of soil area. This cage should be sunk in the ground to a depth of at least 15 inches. Either grooved boards or galvanized sheet iron can be used in making this cage.

When a known number of larvae are introduced to this cage accurate checks can be made on their feeding habits and control experiments be carried on over several years without fear of the larvae escaping. A rectangular screen top may be made to fit this cage, allowing the adults to emerge normally and their habits to be studied. A series of these one thousandth acre cages can be arranged, so that a variety of habitats can be provided and all the different broods of the wireworms kept under experimental control.

Conclusion

The writer has used with success all the different methods and cages herein described and believes that with proper adaptations most of them

can be used successfully in other regions and with other species. It is hoped that this paper will answer satisfactorially in part the many inquiries received during the last year or two from economic entomologists regarding the methods of rearing wireworms.

The meeting was adjourned to meet next year with the Pacific Division, American Association for the Advancement of Science.

MIGRATION—AN IMPORTANT HABIT OF THE EUROPEAN CORN BORER

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ABSTRACT

This paper deals with the migratory habits of the European corn borer, *Pyrausta nubilalis* Hubn., in the heavily infested area of Massachusetts. Evidence obtained from study of the insect in the field is presented, showing that the larvae sometimes migrate in large numbers, particularly from over-populated corn stalks. It is shown that this movement is greatest on the warm nights of late summer. Over-wintering of larvae in locations, other than the host plant, is discussed.

This information has a distinct and important bearing on the field measures used to reduce the number of this insect. If larvae migrate in appreciable numbers from host plants before such infested plants are destroyed, and find hiding places where they successfully pass the winter, the effectiveness of such control measures may be greatly reduced. Knowledge of the hiding places of migrating larvae is important so that more effective control measures may be found.

The migratory habit of the European corn borer (*Pyrausta nubilalis* Hübn.) is important, becoming very important when the insect is particularly abundant. In such cases, should a large number of individuals leave the food plant in which they had been feeding to seek other or fresher food, to seek more advantageous winter quarters, or because of an over-population of larvae for which the food is inadequate, the effectiveness of control measures such as the destruction of crop remnants may be considerably reduced. If these migrating larvae find concealment in unexpected or unusual places a sufficient number may survive to produce a destructive infestation the following year, notwithstanding that the "clean up" campaign has been waged with apparent thoroughness and care.

During 1922 in eastern Massachusetts an excellent opportunity existed for the study of this important subject. During August and September of that year when larvae of the second generation were present in the field, individuals were more abundant than at any

previous time in the history of this insect in the United States. In some fields the infestation was at the rate of from one and a half to two millions of borers per acre of sweet corn. Such great abundance of the insect caused, in some instances, an overpopulation of borers or, there were present in some fields a larger number of larvae than there was food present to satisfy.

Migrating larvae were then very numerous and during warm nights on visiting such a corn field thousands of larvae might be found moving about. With the coming of dawn, however, all were again invisible having entered the corn stalks from which they had issued under cover of darkness, bored into fresh food if such had been found, or they had found places in which to hide during the day.

To obtain information as to the extent of this migratory habit a series of 47 traps were placed in an experimental plot of about 1⅓ acres where corn of different types, flowers and vegetables were being grown and where larvae of the European corn borer were very numerous. The trap used consisted of a board 3 feet long by 4 inches wide, one long edge of which was sharpened so as to set firmly upright in the soil. A detachable cover was placed on top and extended about an inch on either side. Just under this cover strips of corrugated card board an inch wide were tacked to the side of the upright board. Migrating larvae finding this trap across their path and being unable to pass beneath the trap because it set in the soil had either to go around it or pass over it. If they chose the latter alternative they would find the corrugated card board and this being an ideal hiding place, they would remain. These traps were examined each morning where possible. In figure 5 the number of larvae found in all these traps each morning is shown graphically.

These traps were in operation from September 16 to October 14. During that time 1904 larvae were recovered from them, the greatest number of larvae on any one day being 186 and the greatest number from one trap for one day 23. The greatest number taken from one trap for the whole period was 223. The larvae caught in these traps must have been a very small per cent of the total number of larvae that were migrating but this information indicates that migration was very extensive.

The migration as indicated from a study of the records of these traps was greatest from corn which was overpopulated to flowers and vegetables nearby but the movement was very general over all the cultivated area.

The northeast side of this cultivated area was bordered by a row of willow trees some 20 feet from the edge of cultivation, the intervening space being in grass. Along this edge (358 feet) three traps were placed about 15 feet from the edge of cultivation. In these three traps a total of 109 larvae were recovered during the whole period of observation indicated above, the greatest number in the three traps for any one night being 29 and the greatest number in one trap one night being 19. The 9 feet covered by these traps is but a very small fraction of the total distance along this side of the field, so that from these indications it may be safe to say that a considerable number of larvae moved out of the cultivated area and sought some location other than the food plant in which to spend the winter.

In overwintering cages placed for the purpose of observing whether the larvae of this insect were able to successfully pass the winter in sod, 13 pupal cases from which adults had issued in the spring were found in rolled up maple and elm leaves. A total of 50 larvae were introduced into these cages in the fall. This is a significant point in connection with the extensive migration described above.

About a quarter of a mile from the plot previously described there is a small area of bog which in the summer of 1922 had grown up to a nearly pure stand of Polygonum sp. and these plants, common hosts of the insect, were well infested with larvae. Along one side of this bog on rising ground there is a row of old apple trees.

Towards the middle of September of this year it was observed that windfall apples under these trees were riddled by larvae of the European corn borer. Investigation and recovery by the use of migration traps showed that the larvae were migrating in great numbers from the polygonum and were moving towards higher ground either in search of fresh food or of hibernating quarters. The condition of the windfall apples showed that they had satisfied the first mentioned desire while on examination of the trees showed that some of the larvae at least had taken refuge there. Under the rough bark, in cells not unlike those in which larvae of the codling moth spend the winter, the corn borer larvae were found in some numbers and others had penetrated the rotten wood of stumps that remained after limbs had been removed. Subsequent examinations through the winter and following spring showed that not only did larvae spend the winter under the bark but that they pupated and adults emerged, the live pupae and empty pupal cases from which adults had issued being recovered from cells under the bark. From previous experiments it is known that the burrowing of larvae into

Larva of the European corn borer in winter cell under bark of apple tree.

Pupation of European corn borer in fallen leaves. Two leaves are broken open to show the pupal cases from which adults have emerged, two are shown in the condition as found, the pupa being protected within the rolled up portion of the leaves.

wooden posts is common and that in such quarters some of the larvae are able to transform.

On September 21, 1922 it was observed that a farmer at Winchester, Mass., had attempted to plow under a field of about ¼ acre of very heavily infested sweet corn. The plowing was poorly done and the operation resulted in a great migration of the larvae in all directions. A number of plants not previously known to be attacked, were found to be harboring a considerable number of larvae. The first generation larvae of 1923, direct descendants of larvae of the fall migrating brood mentioned in this instance, were abundant and occasioned considerable damage to sweet corn in this section. This was caused probably in a large measure by successful overwintering of migrating larvea.

In the spring examination of weeds it is often noted that plants that normally pass the winter in good condition contain many more larvae than could possibly have obtained sufficient food to complete growth from these plants, while plants which collapsed contained relatively few larvae altho evidence showed that many larvae had fed through the stalks. Thus in cocklebur (*Xanthium* sp.), which usually stands well over winter, as many as 200 individuals have been found in a single plant which is several times the number of larvae that could have obtained sufficient food to grow to maturity from a single plant. Here, then, is evidence of considerable fall migration not to be explained by any agricultural practice, but indicating a general search for more favorable winter quarters by larvae of this insect.

We have shown that a considerable migration of larvae of the European corn borer from their normal food plants to other winter quarters, takes place in the fall during a year of great abundance of the insect. If this migration occurs before the food plants are burned or otherwise destroyed,the effectiveness of such control measures is much reduced and a sufficient number of individuals may survive to cause serious infestation the following year. It is interesting to know if a like movement of larvae takes place in the spring, for example from corn stalks that have remained over the winter in piles.

On April 12, 1923 two piles of sweet corn stalks each composed of some 100 stalks, that had remained in this condition over winter, were surrounded by 14 migration traps of the type previously described, the traps being placed about 10 to 15 feet distant from the corn stalks. The number of larvae that were recovered from these traps daily is shown graphically in Fig. 16. These piles of corn stalks were placed along the edge of the plot first referred to on the side near the row of

from which adults have emerged, two are shown in the condition as found, the pupa being protected within the rolled up portion of the leaves.

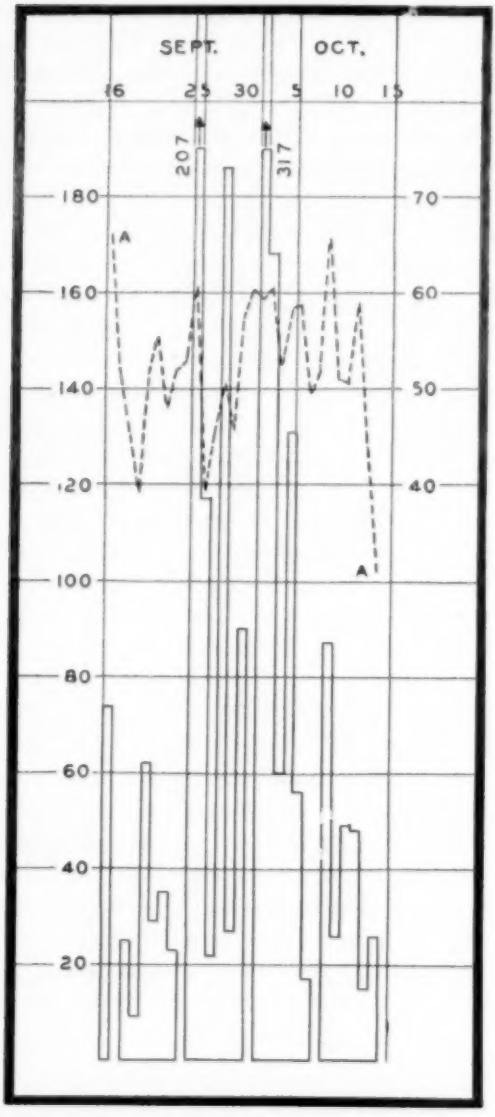

Fig. 15.—Comparison of the number of migrating larvae recovered daily in the fall of 1922 with the mean night temperatures. The graded scale to the left indicates number of larvæ and applies to the blocked-in area. The scale to the right applies to the mean night temperatures shown by the broken line AA. Blank spaces in the record of number of larvae mean that traps were not examined on those days, the record for the day immediately following showing the migration of two nights.

willow trees. Of the total number of larvae (504) found in these traps over the whole period of spring observation, 414 were taken from traps placed between the piles of corn stalks and the row of trees. For some unknown reason in this instance as well as in the observations made in the fall, it seemed that the migration of larvae toward the northeast was much greater than in other directions. However toward that direction there was a considerable accumulation of fallen leaves and other places suitable for hiding, including a few weeds. These remarks apply only to larvae that left the cultivated area. Those moving about in the cultivated area during the fall seemed to move toward fresh food as a usual thing.

Within piled up corn stalks there is also an interesting movement of larvae, those in the centre of the pile where the stalks remain wet, deserting such stalks and moving to the outer dry stalks where conditions for pupation and emergence are much more favorable and where the direct benefit of the sun is felt much sooner than would be the case in the centre of such piles. On May 12, 1921 an examination was made of such a pile of corn stalks to obtain information on this point. In 46 stalks partly wet and partly dry—stalks that extended from the centre of the pile to the outside—there were found:

	Wet portion	Dry portion
Live larvae	3	173
Dead larvae	6	16
Pupae	0	2

In 50 dry stalks from the outside of the pile there were found: Live larvae, 301; Dead larvae, 26; Pupae, 46.

In 50 wet stalks from the centre of the pile there were found: Live larvae, 2; Dead larvae, 4.

In the above instance stalks were on an average equally infested in the fall and larvae remained distributed through the whole pile until it became warm enough for them to become active in the spring.

This movement of larvae in the spring is different from the fall migration in that in the spring the larvae apparently seek only favorable places in which to transform while in the fall they seek not only more likely localities in which to spend the winter but also in many cases fresh food to enable them to complete growth.

We have previously stated that on warm nights of late summer and early fall migrating larvae are to be found very active while such activity ceases with the coming of day when the larvae seek shelter during the hours of daylight. In fact larvae outside of their burrows are very in-

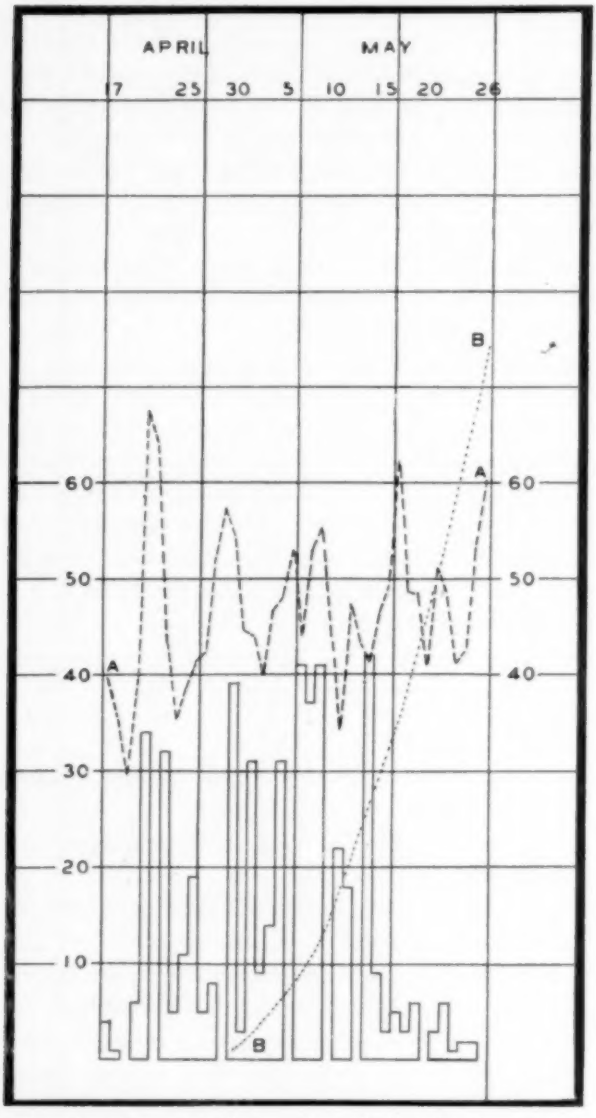

Fig. 16.—Comparison of the number of migrating larvae recovered daily in the spring of 1923 with the mean night temperatures. The scale to the left indicates number of larvae which is shown by the blocked-in area. The scale to the right applies to the mean night temperatures shown by the broken line AA. Progress of pupation is shown by the dotted line BB. Blank spaces in the records of number of larvae means that traps were not examined on those days, the record for the day immediately following showing the migration of two nights.

frequently seen during the day. In figures 15 and 16 the mean night temperatures are compared with the larval migration as indicated from daily recoveries from migration traps. Night temperatures are used in preference to means for 24 hour days because it is the temperature of the hours from dusk to dawn that influences directly the activity of the larvae, since it is then that the larval migration takes place. The mean night temperature was obtained by averaging readings of 8 P. M., 10 P. M., 12 P. M., 2 A. M. and 4 A. M. In the case of the spring migration (Fig. 16), the progress of pupation is shown and it is interesting to note that some larvae continue to migrate after pupation is well advanced. A study of these figures will show that usually the extent of the migration on any night bears a distinct relation to the mean night temperature, becoming most heavy as a rule when the mean night temperature approaches or exceeds 60 degrees F.

Conclusions

Migration of larvae of the European corn borer may in times of great abundance of the insect, be extensive, the larvae moving in the fall to seek fresh food and to locate desirable winter quarters and in the spring to find favorable places for transformation to adults.

Such migrating larvae may successfully pass the winter in rolled up leaves, under the bark of trees, in burrows in wood, or in plants not favored as food plants and may in such locations successfully transform to adults.

When migration to such locations is at all extensive and when it takes place in the fall before crop remnants are destroyed by burning or other means, the effectiveness of such control measures is considerably reduced since a sufficient number of larvae may survive to cause a destructive infestation the following year.

THE BIOLOGY OF ANOMALA KANSANA (SCARABAEIDAE, COLEOP.)

By Wm. P. Hayes and J. W. McColloch,
Kansas Agricultural Experiment Station

Abstract

This paper discusses the economic importance of this recently described species. Its life history, with the length of the various developmental stages, is considered. It is found to have a one-year life cycle. The adults appear in June and July. Eggs are laid in the soil and the larvæ live over winter. Pupation occurs in late May, June, and early July.

Introduction*

During the course of studies on the white grubs and May beetles of Kansas, a new and important species of the genus *Anomala* has been under observation for the past few years. Considerable data on its life history having accumulated, an account of these are here set forth.

The species has been recently described (Hayes and McColloch, 1924)[1] as *Anomala kansana*. The writers are indebted to Mr. Warren Knaus for calling their attention to the fact that this species was undescribed.

Economic Importance

From its relative abundance and somewhat general feeding habits, this species can be regarded as of economic importance and one which

Fig. 17.—*Anomala kansana* adult, enlarged (Drawing by S. Fred Prince).

may prove a troublesome pest. The adult feeding habits are crepuscular and quite varied, having been found on strawberry leaves, sorghums, corn, wheat heads and wheat in the shock, sweet clover, sumac, rye, dogwood, pasture grass, lamb's quarter, smartweed and horse thistle.

The larvæ likewise are quite general feeders and have been collected in a number of different situations, such as under logs, on sand dunes, in corn-fields, under rocks in woodland, in wheatfields, gardens, blue-grass sod, alfalfa land, oat-stubble, potato fields and roots of Sudan grass. The determination of the specific identity of grubs found in these situa-

*Contribution No. 328 from the Entomological Laboratory, Kansas State Agricultural College. This paper embodies some of the results obtained in project No. 100 of the Kansas Agricultural Experiment Station.

[1]Hayes, W. P., and McColloch, J. W., A New Species of *Anomala*. Ent. News 35:138–140, 1924.

tions was made by rearing them to maturity. It is of interest to note that of approximately 200 grubs collected and reared, 190, or 95 per cent, were found in wheatfields. This large proportion may be partly due to the ease with which collections may be made behind the plow. It is evident from the general feeding habits and the preponderance of individuals in wheat land that the species is capable of doing some damage, especially to wheat.

Life History

Adult. The beetles are nocturnal in habits, appearing at dusk to feed, after which they are readily attracted to lights. The beetle (fig. 17) is dark brown to piceous in color, with lateral margins flavo-testaceous; ventrally it is fusco-testaceous to rufo-testaceous with a faint, greenish, metallic lustre; the legs are rufo-testaceous and in size the species varies from 11 to 12.5 mm. long, and 5 to 6.75 mm. wide.

The insects are relatively abundant every year. In this study they were found more frequently at lights in 1921 and 1922, but after their food habits were discovered in 1923, they were found more abundantly on food plants. The total numbers collected and the numbers reared from collected grubs and from eggs hatched in the field laboratory are shown in Table I.

Table I—Showing the Relative Abundance of Anomala kansana

Source of collections	1921	1922	1923	Total
At lights	16	82	32	130
On food plants	1		373	374
Miscellaneous	1		2	3
Collected grubs	157*	9	43	209
From eggs		16		16
Total	175	107	450	732

*Includes three specimens reared in 1919.

As shown by Table I, sixteen individuals were raised through all their stages from egg to adult. It may also be noted that of several hundred grubs collected in the fields, 209 were reared to adult. The length of the various stages as discussed in this paper are based on these numbers.

T his species is attracted to electric lights during June and July. In 1921, their first appearance at lights was June 13 and the last June 29. In 1922, they were present at lights from June 9 to July 12, and in 1923 from June 23 to July 16. These dates correspond closely to the entire period of flight for the three seasons, except that in 1921 they were

found on food plants one day earlier (June 12) than at lights and in 1923 they were found three days earlier (June 20) on sorghum and wheat plants. The length of the flight period in 1921 was shorter than the other two flights extending over a period of only 17 days. In 1922, the flight period was 33 days and in 1923, 26 days, making an average flight period for the three years of approximately 25 days.

The adults apparently exhibit no strong preference for any certain type of soil. As previously stated, most of the grubs have been collected in wheat fields, but they have also been found in corn land, both on upland and lowland, in sandy dunes along the Kansas river, in sod land, and in rocky woodland.

Mating was observed in the laboratory only, when it was noted to occur on the surface of the soil in rearing cages in the late afternoon. In 1921, the first eggs laid in laboratory cages were found on June 15, only three days after the first appearance of flight was noted. In 1922, the first eggs were found June 14, five days after appearing at lights and in 1923 the first eggs were observed June 26, being 6 days from the time they were first noted on food plants. From this it can be conjectured that the pre-oviposition period is relatively short or that mating may occur in the soil before emergence, which fact seems doubtful, notwithstanding the fact that the Scarabæid genera *Ligyrus* and *Ligyrodes* mate in the soil. Females were observed mating after oviposition had occurred.

Egg. The eggs are laid in the soil, and, like other Scarabæid eggs, increase somewhat in size after being deposited. The number of eggs laid by a female was not noted, but one dissected female was observed to contain 26 full sized eggs. When freshly laid, the eggs are about one millimeter wide and 2.25 millimeters long. They are milky white in color, elongate oval in shape, changing to a more spherical shape as development proceeds.

Egg laying began in 1921 on June 15; in 1922 on June 14, and in 1923 on June 26. The length of the egg stage varied from nine to 19 days with quite different averages for the four seasons observed. The maximum, minimum and average periods of egg development for the years 1920 to 1923 are shown in Table II.

Larva. The larvæ of *Anomala kansana* closely resemble the larvæ of other species of this genus and have much in common with other grubs of the family Scarabæidæ. Upon hatching, the young larvæ are about twice the length of the eggs from which they emerge and when fully grown are about 24 millimeters long and seven millimeters wide

TABLE II—THE LENGTH OF THE EGG STAGE OF ANOMALA KANSANA

Year	Number of eggs	Maximum days	Minimum days	Average days
1920	5	15	13	14.6
1921	486	19	9	12.6
1922	40	16	9	13.9
1923	101	17	9	11.9
Total extremes and average	632	19	9	12.2

behind the head. The head is tan colored and the body creamy-white in color.

The larvæ began hatching in 1921 on June 27; in 1922 on June 24, and in 1923 on July 9. The first molt occurred from 12 to 36 days after hatching with an average period for the first instar of 20.5 days for 69 cases observed. The second molt occurred the same season from four to as many as 52 days after the first molt. For 46 molts observed, the average period of the second instar was 16.8 days. The winter is passed in the third larval instar, which varied from 285 to 311 days, with an average of 301.6 days for 21 cases. Prepupation begins in late May and early June, having been noted to occur as early as May 28 and as late, in an extreme case, as July 1. The prepupal stage for 22 grubs reared from egg to pupation varied from three to seven days with an average of 4.1 days. For 83 grubs reared from collections made in the field, the average was 4.02 days, with extremes of two to 16 days. The average for the two groups was 4.06 days.

The total length of the larval stage, including the prepupal stage, was noted for 23 individuals and found to average 336.3 days, with a minimum period of 322 days and a maximum period of 345 days. The length of the larval stage from hatching to prepupation was noted in 20 instances where extremes of 280 to 308 days were observed, with an average of 298.3 days. These data are summarized in Table III.

TABLE III—THE LENGTH OF THE LARVAL STAGE OF ANOMALA KANSANA

Period	Number of individuals	Maximum days	Minimum days	Average days
Hatching to first molt	69	36	12	20.5
First molt to second	46	53	4	16.8
Second molt to prepupa	20	308	280	298.3
Second molt to pupa	21	311	285	301.6
Prepupa to pupa	105	16	2	4.06
Total larval stage	23	345	322	336.3

PUPA. The pupa, when freshly transformed, is creamy white in color. As development proceeds, the darker colors of the adult insect are assumed. Pupation occurs during late May, June and early July, having been noted as early as May 30, and as late as July 11. The length of the pupal stage varies from eight to 20 days. In all, 212 pupæ were observed for the length of this stage. Among grubs reared from eggs, the pupal stage averaged 10 days for 16 pupæ. Grubs collected in the field averaged 12.5 days in 1922 for 153 instances, and in 1923, 43 pupæ had an average period of 9.9 days. These data are summarized in Table IV.

TABLE IV—THE LENGTH OF THE PUPAL STAGE OF ANOMALA KANSANA

	Year	Number reared	Maximum days	Minimum days	Average days
Collected grubs	1922	153	20	9	12.5
Collected grubs	1923	43	17	8	9.9
Reared grubs	1922	16	12	8	10.

SUMMARY

This new species of the genus *Anomala*, because of its widely varying feeding habits and rather general occurrence in the region in which it is found, bids fair to become of considerable economic importance. The beetles feed at dusk and fly to lights. Eggs are laid in the soil in June and July and require an average of 12.2 days for hatching. The larvæ live in the soil over winter. Molting occurs twice. The first molt occurs on the average 20.5 days after hatching and the second molt, an average of 16.8 days after the first molt. The total larval stage varied from 322 to 345 days, with an average of 336.3 days. From this should be subtracted an average of 4.06 days for the prepupal stage. The pupal condition lasts from 8 to 20 days. Pupation occurs in late May, June and early July. After transforming to the adult stage, the beetles soon appear above soil to feed and reproduce.

THE CORRECT NAMES OF THE LEAFHOPPERS INFESTING THE APPLE AND POTATO

By E. D. BALL

ABSTRACT

There has been much confusion and misunderstanding with respect to the scientific and common names to be applied to the three species of leafhopper infesting the apple,

namely *Typhlocyba rosae*, *Empoasca maligna* and *E. fabae*. A key to the insects and another to the injury will assist in determination. The earliest species described by Harris and Walsh are for the first time considered and their scientific names applied. This should give a stable scientific nomenclature and if the common names recommended are adopted, confusion can be avoided in the future.

There has been much confusion and uncertainty in regard to the number of species of leafhoppers infesting the apple as well as to the scientific and common names that should be applied. The fact that two of these species also seriously injure other economic plants has served to complicate the situation. Sufficient study has now been made of the subject in different parts of the United States to warrant a fairly definite statement that three species of the *Eupteryginae* (*Typhlocybinae*) and only three are commonly found on apple trees. Parrott (1909) was the first to point this out for New York conditions. Lathrop (1918) working at Geneva differentiated the nymphs and worked out the life histories. Later studies by Childs (1918), the writer (1918), Fenton and Hartzell, (1923) Ackerman, and others, have confirmed these results for the different apple-growing regions of the United States.

These three leafhoppers can be readily separated by the following key.—

A. Nymphs white, adults white or pale golden; two generations of nymphs, the first one early. The Rose Leafhopper (*Typhlocyba rosae* Linn.)

AA. Nymphs and adults green.

B. Adults stout, deep green, with a blunt head, a single generation of nymphs appearing early. The Apple Leafhopper (*Empoasca maligna* Walsh)

BB. Adults slender, fragile, pale green, with an angled head, two generations of nymphs, the first one appearing late. The Potato Leafhopper (*Empoasca fabae* Harr.)

These leafhoppers may also be separated by the appearance of the injury they cause.

A. White spotting on the upper surface of the *older* leaves, especially in the lower part of the crown of bearing trees, leaves remain flat, (nymphs found on under surface only, eggs winter in bark.)

B. Nymphs and adults white; occur throughout the season on rose and apple. The Rose Leafhopper.

BB. Nymphs and adults green, nymphs early only, adults later and confined to apple. The Apple Leafhopper.

AA. Curling and distortion of young leaves of watersprouts, tips or nursery stock; tips and margins of badly affected leaves turn brown, no white spotting. On potato, apple, beans, raspberries, gladioli, etc. Adults hibernate and lay eggs through a long period. The Potato Leafhopper.

No serious attempt has been made previous to this time to accurately determine or place the earlier described species of *Empoasca* and *Typhlocyba* of Harris and Walsh and thus place our nomenclature of these

economic forms on a stable basis. Woodworth (1888–89) published a preliminary review of the genera but did not attempt to define the species. Gillette (1898) in his "American Leaf-Hoppers of the Subfamily Typhlocybinae" ignored *fabae* of Harris, the genus *Chloroneura* of Walsh, and did not place *C. maligna* or *C. malifica*, the two injurious species from apple which Walsh described under this genus. Hartzell (1924) in his "The Genus *Empoasca* in North America" followed Gillette in the use of color characters for the separation of species and also failed to recognize any of the earlier described injurious species.

A careful study of some of the more common species of *Empoasca* has shown that many of them are widely variable in color characters, ranging all the way from uniform green or yellowish to definitely lined, spotted, banded, or highly ornamented forms. It is therefore probable that when the entire genus is carefully studied there will be other synonyms added to the lists below. These will not, however, affect the name of the species as in this study the older names have all been considered.

In this connection it is well to remember that Harris, LeBaron, Walsh, and Forbes were only interested in discussing species sufficiently abundant to be injurious to crops. Walsh described other species because as he states, "Of these six divisions, the four last all comprise species of about an eighth of an inch in length, and of a uniform pale green or yellowish color, with scarcely any markings. These I propose to describe, as they are liable to be confounded with the two foes of the apple and pear." Naturally these must have been representatives of the more common and widely distributed species in the region. A detailed study of his species bears out this conclusion.

The Rose Leafhopper (*Typhlocyba rosae* Linn.)

This species is white with a golden tinge and is considerably larger than *fabae*. The nymphs are white instead of green as in the two following species. It has two generations annually. The winter is passed as an egg under the bark, usually of a rose bush, the first generation nymphs then live on the underside of the rose leaves, their punctures whitening the upper surface. The adults fly to the apples and the second generation follows *unicolor* in whitening the older apple leaves and doing serious damage. This is in nature a rose pest and both generations may remain on that plant. On the other hand, in seasons of unusual abundance, the overwintering eggs may be laid on the apple. This is the common pest of apples in the northwestern states and is occasionally seriously injurious in

certain localities throughout the apple-growing region. Although reported as *mali*, this is the species that was notably injurious in New England localities in the early season of 1924. It has always been called the rose leafhopper and that name should be continued. It is especially injurious to apples in regions where roses abound. The sweetbriar of the northwest is a constant breeding ground for this species.

The Apple Leafhopper (*Empoasca maligna* Walsh)

Chloroneura maligna Walsh. Prairie Farmer, pp. 147–149, Sept. 6, 1862. Reprint Proc. Bost. Soc., Nat. Hist. Vol. 9, p. 317, 1864.
Empoasca unicolor Gill. Proc. U. S. Nat. Mus., Vol. XX, p. 731, 1898. Hartzell: Proc. Ia. Acad. Sci., Vol. 30, p. 100, 1924.

This species is a beautiful golden green in color, with a bluntly rounding head and is larger, and much less fragile than *fabae*. The nymphs are leaf green. It has a single generation annually and spends its whole life on the apple. The winter is passed in the egg stage under the bark of the twigs. The nymphs appear late in the spring after the apple leaves are well grown; they feed on the under side of the mature leaves and cause a whitening of the upper surface but no rolling or distortion. The adults remain on the trees through the remainder of the summer, laying eggs to pass the following winter. This species is distributed from the Rocky Mountains to the Atlantic and in company with the preceding is responsible for all of the injury to mature apple foliage usually manifested by the whitening of the upper surface of the leaves.

Walsh described this species as the malignant leafhopper because this and the preceding species were supposed to be the cause of fire blight on the apple and pear, thus definitely placing this as one of the two apple-infesting species. With this in mind his description and figure (of the head) are so accurate that there can be no mistake. He says "Differs from the above *malifica* (*fabae*) as follows:—"The color is deeper, the head is almost transverse, its anterior edge forming about half a quadrant; the elytra are subopaque and deeply tinged with green, and the anal vein attains the cross-vein nearly." The figure of the head shows the short blunt head of this species which would alone separate it at once from *fabae*, the other apple species, but when he describes the deeper color, so deep that the elytra are "subopaque" instead of "subhyaline" as in *malefica* (*fabae*), he gives the most distinctive character of *maligna* and one that will definitely distinguish it from any other species found on the apple tree.

This is *the* apple leafhopper; it spends its whole life on the tree and

frequently does serious injury. It should undoubtedly be called the apple leafhopper and the other species named for their preferred hosts.

The Potato Leafhopper (*Empoasca fabae* Harr.)

Tettigonia fabae Harr. Ins. Inj. to Veg., p. 186, 1841.
Tettigonia mali Le B. Prairie Farmer, XIII, p. 330, 1853.
Empoasca viridescens Walsh. Prairie Farmer, Sept. 6, 1862. Rept. Bost. Soc. Nat. Hist., IX, p. 316, 1864.
Empoasca consobrina Walsh. Ditto.
Chloroneura malefica Walsh. Prairie Farmer, Sept. 6, 1862. Rept. Bost. Soc. Nat. Hist., IX, p. 317, 1864.
Typhlocyba photophila Berg. Hemip. Argent., p. 273, 1879. (Vide Gill.)
Empoa albopicta Forbes. 13 Rept. Ill. St. Ent., p. 181, pl. XIV, 1883.

This is a slender fragile pale green species with an angled head. The nymphs are green. Harris described this species as injurious to beans. Most of the early literature speaks of it as an apple or nursery stock pest. It is primarily a potato pest, its attack producing the hopperburn (formerly included under tipburn), that has been so injurious in northern and eastern United States in recent years. In periods of abundance it also attacks watersprouts and nursery stock of apple, succulent growth of raspberries, boxelders, gladioli, and occasionally other trees and shrubs and produces similar burning. When potato fields have been destroyed it may migrate to and seriously injure beans. The mature adults, especially at the mating season, usually exhibit white spotting on the vertex and face, a row of about eight spots on the front of the pronotum and a broad "H" on the scutellum. These markings are not on the chitin but in the tissues beneath and they largely disappear in the dried specimens. No other species occurring in this region could fit Harris' description, particularly "slender, delicate pale green elytra transparent," infests beans in July, especially in dry years.

When the writer found the potato leafhopper (then called *mali*) migrating from potato fields that had been destroyed into adjacent bean fields and destroying them, he became curious as to the identity of Harris' *fabae* and took the first opportunity to examine the types[1] in the Harris collection.

The types were found in a fine state of preservation for so fragile an insect. They bear the label "No. 253 on corn and beans, August 15, 1838." There were originally three specimens on one card of which

[1]The Harris collection is well cared for in the Boston Museum of Natural History and the writer wishes to express to Dr. C. W. Johnson his appreciation of the privilege of examining these and other types.

there remains one entire insect and one with the head gone. Three elytra show the triangular apical cell. The under wings show the single apical cell with a marginal nervure. One specimen shows the forked white marking on pronotum, so distinctive. In every way they are characteristic of the species. A specimen pinned along side marked "Fitch 196" shows all the white markings as commonly illustrated.

LeBaron (1853) found examples of this species damaging the young leaves of the apple and especially young nursery stock and noted that they crumble and roll the young leaves. These examples had all the white markings distinct and not recognizing Harris' species, he described them as *mali*.

Walsh (1862) studied the species of leafhoppers injurious to the apple and pear and described the genera *Empoasca* and *Chloroneura*, the former with a triangular apical cell in the elytra and the latter with a quadrangular one. As this character is widely variable in the different examples of the same species and often on the two elytra of the same example, the genus *Chloroneura* becomes a synonym of *Empoasca*.

Walsh described three new species under each genus. Of these *Empoasca obtusa* Walsh and *Chloroneura abnormis* (= *Dikraneura abnormis* Walsh) have been generally and apparently correctly placed. In republishing this paper in the Proceedings of the Boston Society of Natural History the next year Walsh notes that *E. consobrina* is only a variety of *viridescens* as at that time he had all the intermediate grades. The only difference mentioned was the venation and a slightly yellowish instead of greenish color. As the character of the apical cell is of no value and all pale green *Empoascas* vary to yellowish, this can be accepted as final.

E. viridescens is described as:—head right angled, the apex rounding off, pale greenish, elytra subhyaline with a greenish tinge. A specimen from Rock Island varies in being more yellowish. Length not quite 1/8 in. *E. consobrina* varied only in being sometimes yellowish and slightly over 1/8 in. in length. *Chloroneura malifica* (omitting the variable cell character) is described in exactly the same language as that used for *viridescens* with the addition of "or yellowish" and elytra "at their extreme tip cloudy." Length 1/8 in. Curiously enough these are exactly the additions that the *consobrina* description brings to *viridescens* with one addition,—the cloudy tip,—a character often found in the potato leafhopper. There appears to be little doubt that these descriptions apply to the same species, the only reason for separating them in the first place probably being the unstable generic character.

Walsh calls *malefica* the "culprit leafhopper" and says "occurs on apple and pear leaves. Took a pair *in coitu* under bark, early in the spring, in the woods." In another place he states that this species and *maligna* are supposed to be the cause of fireblight. In the *Prairie Farmer* of the next year (April 4, 1863) he discussed this further in connection with eggs found in apple twigs which he identified as the eggs of *malefica*. This species hibernates in the adult stage which agree with his finding them under bark in the early spring but would not agree with his identification of winter eggs. A study of his description and figures of the eggs shows conclusively that they were those of a tree-hopper (*Ceresa*) and not of any leafhopper. As this is the only apple-infesting species of *Empoasca* that winters as an adult, there could be little question of the correctness of the determination on that ground alone, but when taken in connection with Walsh's accurate comparison with *maligna*, the other apple-infesting species, the identification is definite and complete.

This species is a much more serious pest of potatoes than it is of apples, in fact it is *not* ordinarily an apple pest but only a nursery stock pest. Although named *fabae*, it is only secondarily a bean pest and should undoubtedly be called the potato leafhopper.

Much additional confusion has arisen from the unstable character of the white markings of this species. A majority of the mounted material shows no markings at all—such examples are usually determined as *viridescens*. Others show three spots on the pronotum and a pale line on the scutellum and are often determined as *flavescens* while the few that show the complete spotting have been determined as *mali*.

Bibliography

1889 Woodworth, C. W. North Amer. Typhlocybini. Psyche, Vol. V, pp. 211–214.

1898 Gillette, C. P. Amer. Leaf-Hoppers of the Subfamily Typhlocybinae. Proc. U. S. Nat. Mus., Vol. XX, pp. 709–773.

1909 Parrott, P. J. "Scientific Notes", Jour. Econ. Ent. Vol. 3, p. 79.

1918 Childs, Leroy. The Life History and Control of the Rose Leaf-Hopper. Oreg. Exp. Sta. Bull. 148.

1918 Lathrop, Frank H. Leafhoppers Injurious to Apple Trees. Geneva New York Exp. Sta. Bull. 451.

1919 Ball, E. D. The Potato Leafhopper and the Hopperburn that it causes. Wis. Dept. Agric. Bull. 23, pp. 76–102.

1923 Fenton, F. A. and Hartzell, Albert. Bionomics and Control of the Potato Leaf-hopper. Ia. Exp. Sta. Research Bull. 78.

1924 Hartzell, Albert. The Genus Empoasca in North America. Ia. Acad. Sci. Vol. 30, pp. 87–133.

See Gillette, Fenton and Hartzell for further references.

Scientific Notes

Recurvaria nanella Hübner occurred in considerable numbers in the vicinity of Harrisburg, Pa., on peach, quince, sweet cherry and plum. The larvae caused considerable damage to the young leaves. In some instances as many as fifty per cent of the terminals were infested. The adult of this species was reared and identified by Mr. Carl Heinrich from material sent to him by the writers.

T. L. GUYTON and A. B. CHAMPLAIN, *Pa. Dept. of Agri., Harrisburg*

Destruction of Canada Thistles by *Pyrameis cardui* Linn. In north central and northwestern Ohio, the larvae of the Painted Lady butterfly have been found in great numbers feeding on Canada thistle. In some sections their abundance was so great that an uninfested plant could not be found. The leaves, blossoms and upper part of the stem were usually entirely destroyed. They attracted much attention and were widely heralded in newspapers as "new friends of the farmer."

C. R. CUTRIGHT, *Assistant Entomologist, Agricultural Experiment Station, Wooster, Ohio.*

Strategus antaeus Injuring Peach. During the last week in June adults of this species were found burrowing under ground and girdling one- and two-year old peach trees in the vicinity of Harriman, Tennessee. Injury was quite severe only in those orchards that are located on new ground and with an abundance of oak stumps through the peach orchard. As the larvae of this species are known to feed on decayed oak leaves and roots, it is more than likely that they bred up from the decaying oak stumps. The injury first manifested itself by yellowing of the leaves and later by dying out completely.

S. MARCOVITCH, *Agr. Expt. Station, Knoxville, Tenn.*

The Western Corn Root Worm in Connecticut.— On August 29, 1923, the writer collected in the flowers of *Hibiscus moscheutos*, at Granby, Conn., two slender green Chrysomelid beetles. A visit to the same place on September 5 of this year showed me that these beetles were quite common on aster, calendula and some other kinds of flowers in the garden. This beetle has been identified as *Diabrotica longicornis* Say, by Mr. M. P. Zappe, Assistant Entomologist of this Station. This species, which has also been collected recently at Cornwall, Conn., by Mr. K. F. Chamberlain, occurs in the southern and middle western states, but it is believed that it has not heretofore been recorded from Connecticut.

W. E. BRITTON, *Conn. Agr. Expt. Station, New Haven, Conn.*

A European Leaf-Miner of Birch.— During the summer of 1923, in several localities in Connecticut, leaves of the gray birch, *Betula populifolia*, particularly those at the tips of young sprouts, were being mined by some larva which made a broad "blotch" mine. Some material was collected that season but the adults were not reared. This season at my suggestion, material was gathered by Mr. R. B. Friend, Assistant Entomologist of this Station. On August 6th, Mr. Friend obtained a number of small sawflies of both sexes. Specimens were sent to Mr. S. A. Rohwer of the U. S. National Museum who has identified it, at least provisionally, as the European *Fenusa pumila* (Klug) which up to this time was not known to occur in the United States. Dr. Felt informs me that he has observed the work of this leaf-miner generally in eastern New York State and also collected material.

W. E. BRITTON, *Conn. Agr. Expt. Station, New Haven, Conn.*

A spittle insect (*Lepyronia quadrangularis*) is causing noticeable injury to corn in Carroll County, Arkansas. In the infested area, covering several acres, the spittle insects could be seen on some plants in aggregations of 20 to 50, on the under surface of the leaves, in the axils and on the tassels. In some instances about a hundred insects were observed on a single plant. As a result of the attack, many of the plants had turned brown and the stalks were dying. The corn is near a timothy field which had been cut about two weeks ago. Apparently, the field was severely infested with the spittle insects, and when their food supply was taken away they migrated to the corn. Although so far as I know, *Lepyronia quadrangularis* has not been reported on corn, it apparently finds this host plant entirely satisfactory.

W. J. BAERG, *Entomologist*

Calcium Cyanide Kills Vespa infernalis; On Sept. 9th Dr. C. P. Gillette received a phone call asking for aid in destroying a wasp infesting a house in Fort Collins. The wasps were causing considerable annoyance in that members of the family were being stung quite severely. The writer was asked to look the situation over and advise a remedy.

The wasps were found to be inhabiting the house at some place between the sill and the foundation. Wasps were flying in and out in great numbers, and, due to the location, to gain access to the nest was impossible without removing part of the foundation. Burning sulphur fumes injected into the opening failed to give the desired results. Calcium cyanide was then tried. The dust was blown in between the entrance and the foundation, also a small amount of dust was applied to the ground just below the entrance. The results were interesting. None of the wasps on the outside of the nest were observed to pass in over the cyanide and make their way out again. Wasps on the outside would come in from the field, and in an endeavor to gain entrance to the nest, would be overcome by the cyanide and fall to the ground where they were killed by the cyanide there. A 100% kill was secured.

GEO. S. LANGFORD, *Colorado Agricultural College*

A New Egg-Parasite of the Codling Moth.— During the months of June and July 1924 while making field observations on the hatching period of the codling moth eggs on English walnuts in Ventura County, Calif. it was noticed that about 3 per cent of the eggs were parasitized.

The larval parasite was visible within the egg, moving nematode-fashion. When half grown its alimentary tract shows up clearly for it is brown in color and opaque. In the pupal stage the parasite is hidden from view by the blackening of the egg shell immediately above it. (This change in the egg shell also occurs when the larva of *Trichogramma minutum* pupates.) The newly formed pupa is light yellow and lies within the egg shell surrounded by masses of brown excrets.

About twenty of these parasitized eggs were brought into the laboratory. When the parasites had pupated they were removed from the nuts and placed in a petri dish where they emerged.

According to Mr. Timberlake this parasite is a species of the genus *Prospaltella*.

STANLEY E. FLANDERS, *Entomologist, Saticoy Walnut Growers Assn.*

Wireworms injuring sugar cane.—A report was received in June from a sugar plantation near Morgan City, La., that wireworms were injuring sugar cane in the lower fields. An investigation showed that about 250 acres of stubble cane has been completely destroyed, together with about 50 acres of plant cane. All was in reclaimed

land near the woods, where there were many pieces of rotten wood in which the insects feed. Further observations showed that a few of the wireworms were on higher ground.

Larval specimens submitted to Mr. J. A. Hyslop of the Bureau were determined as *Melanotus sp.*

Various experiments in the control of this pest have been started.

As far as known to the writers, this is the first report of wireworms seriously injuring sugar cane in Lousiana. It is believed that the land newly reclaimed from the swamp was naturally infested with them, and finding sugar cane at hand they turned their attention to this crop. They feed on the "eyes" of the planted seed cane, and bore into the young plants below the surface of the ground in a manner somewhat similar to the sugar cane moth borer, *Diatraea saccharalis.*

It is to be noted that corn in adjoining fields appears to be free of attack.

W. E. ANDERSON, *Louisiana State Entomologist*
T. E. HOLLOWAY, *Bureau of Entomology*

Wohlfartia vigil Walker Attacking Man.— A first stage larva about 0.6 mm. long, presumably of this species of flesh fly, was removed, along with several others, from the conjunctivae of a man affected with some conjunctivitis, and resident in Cattaraugus County, New York State. A very small cyst was observed, which contained several living maggots. Walker (Journ. Parasit., 7:1–7, 1920) has recorded two cases of infestation in 1920 and another in 1921 (Ibid. 9:1–5, 1922), all infants with the infestations characterized by boil-like sores on the exposed upper parts of the body, especially the neck and arms. This appears to be the first American record of adult infestation of the eye, such as is recorded for the European *W. magnifica*. Infestation is presumably most likely in heavy sleepers, especially somewhat defenseless young children.

E. P. FELT

The Apparent Eradication of the Argentine Ant from Fayette, Mississippi.— During the summer of 1922 the Argentine ant was discovered at Fayette, Mississippi by one of the Plant Board inspectors, Mr. G. W. Alexander.

A survey made during the late summer revealed the fact that the infestation covered only one and a half blocks. Realizing that the chances for eradication were remarkably good, the Plant Board advised the authorities to undertake successive fall campaigns for the purpose of eradicating the ants. The town authorities readily agreed to this, so in the fall of 1922 the writer and Mr. Alexander distributed 750 cans of poison throughout the infested area. This was at least twice the amount usually put on blocks of the same size in larger campaigns. At the time the poison was put out, the ants were sufficiently abundant to be seen here and there without any particular search for them.

The latter part of the next summer (1923), the writer visited Fayette and went carefully over the infested area hunting for ants, but only two small colonies were found. Conversations with people living in the infested area convinced the writer that the ants had become almost exterminated by the first poisoning. A second campaign was put on in the fall, the same amount of poison being used as previously.

In June, 1924, the writer spent almost two days going over the infested area hunting for Argentine ants but found none. Numerous native ants were present in the once infested territory, such species as the fire ant, *Solenopsis geminata* Fabr., the tiny black ant, *Monomorium minimum*, Buckley, the small sugar ant, *Prenolepis*

nylanderia and *Pheidole dentata* Mayr. being unusually common. Not a person in the area could be found who has seen or been troubled by the Argentine ant since the second batch of poison was put out.

It is, of course, a little early to say positively that the Argentine ant has been eradicated from Fayette, yet the writer has every reason to believe, and does believe quite positively that the pest has been eradicated from this town.

So far as known no other town in the United States has ever accomplished eradication of the Argentine ant. This experience should be an incentive to other towns to fight the ants as Fayette has done.

M. R. SMITH, *Ant Specialist, Mississippi State Plant Board, A. & M College, Mississippi.*

The so-called Cotton Flea.— During 1923 and 1924 considerable attention has been attracted principally in southern Texas to a new and severe form of injury to cotton. The very young squares are blasted, the number of fruiting branches is reduced and the main stem of the plant grows excessively tall. All varietal characteristics are obliterated and the plants resemble "sterile rogues." This injury reached its climax in South Texas in 1923. During that season the loss from this cause was much greater than from the boll weevil. In hundreds of fields no crop whatever was produced. In 1924 the injury has been much less but is still very considerable in Calhoun and neighboring counties on the coast of Texas. In one field recently (July, 1924) examined only 765 bolls were found on 1000 plants. What appears to be the same form of injury, has recently (July, 1924) been reported from Georgia and South Carolina.

It is the consensus of opinion among farmers in Texas that the injury is caused by an insect, *Psallus seriatus* Reuter, a Capsid, is the species generally pointed out. This insect was reported as an enemy of cotton some years ago by Dr. L. O. Howard on material submitted by the late J. D. Mitchell of Victoria, Texas. It is recorded by Van Duzee from Texas, Arizona, New Mexico, Florida and various northern and other western states.

During 1923 an investigation of this problem was undertaken in Texas. It dealt largely with epidemiological considerations. The results obtained suggested that the so-called flea might have a connection with the injury described. During 1924 exact experiments were conducted in Calhoun County, Texas, in which, by the application of dust insecticides beginning early in the season the hopper was eliminated from the series of plots in different fields, the plant reactions being carefully observed in the treated and untreated areas. Other experiments have dealt with the introduction of large numbers of hoppers into cages in which cotton plants are growing. The work has not yet advanced far enough to warrant any very definite conclusions but there are strong indications that the insect transmits a virus of some kind, thus bringing about the profound changes in the habit of growth of the plant, which are entirely out of proportion to the number of the insects which have ever been found in the fields. A full report on these experiments including the results of observations on the occurrence of the trouble in Texas and other states will be prepared at the end of the season.

W. D. HUNTER, *Bureau of Entomology*

Notes on Winter Mortality of the three Coccids *Pseudaonidia duplex* (Ckll.), ***Chrysomphalus aonidum*** (Linn.), **and *Chrysomphalus dictyospermi*** (Morg.), **at New Orleans, Louisiana.** On January 6, 1924 when the official minimum temperature of

19°F. was recorded in New Orleans, much of the sub-tropical vegetation was severely frozen and many of the more tender plants killed.

In connection with the semi-weekly studies of the seasonal history of the camphor scale, *Pseudaonidia duplex* (Ckll.), on camphor trees, data secured on the mortality of the insects from natural causes,[1] from natural enemies and from freezing, pointed to a distinct increase in the number of dead scales following the cold weather. In these studies it was observed that the body contents of adult female scales, which had died from natural causes or had been killed by parasites or predators were dried or eaten and their appearance was not changed by freezing. The scales recorded as frozen showed a collapsed body wall, oily appearance and discoloration, a condition distinctly different from that of the insects dead from other causes, and this condition indicated that before being frozen the body contents of the frozen scales were normal and these scales living.

The records of the mortality from various causes were determined by counts of material taken from the same twigs at the same time, so that the gradual rise during the winter in the natural mortality does not influence the results. The number of scales recorded as killed by natural enemies after the drop in temperature was about 2% less than the number dead from this cause during the four weeks preceding the cold. No consideration has been given to the influence on the counts of the dead scales which loosened and fell off as the study progressed and it is quite probable that many of the frozen scales were handicapped by a low vitality or an exposed position so that they would have succumbed naturally to the climatic changes of a more normal winter.

The comparison is made of results of observations on the mortality of the camphor scale from January 22, 1924, 16 days after the freeze, at which time the insects had reacted to the cold sufficiently to give accurate information, to February 29, 1924, a total of 12 examinations. The examination of 5225 adult female scales at 12 semi-weekly intervals during this period, showed 2660 or 50.91%[2] dead. Of these 1576 or 30.16% of the total number examined were recorded as killed by natural causes, 840 or 16.08% by freezing, 138 or 2.64% by parasites, and 106 or 2.03% by predators.

Observations during the four weeks previous to the low temperatures showed that 1047 or 28.31% of the 3698 adult female scales examined were dead from natural causes and natural enemies.

Records of the examination of 1859 female camphor scales, collected March 8, 1924 on *Citrus trifoliata* growing below buds of Satsuma orange trees five miles south of Mobile, Alabama, where the minimum temperature is said to have ranged from 10° F. to 14°F. on January 6, 1924, showed 1100 or 59.17% of the total scales dead.

No decrease in the number of natural winter eggs per female has been apparent and in other respects the surviving over-wintering females appear normal. All live male scales had issued from beneath their coverings previous to the freeze.

The data secured from examinations of the Florida Red Scale, *Chrysomphalus aonidum* (Linn), collected on camphor leaves at New Orleans, La. showed 40.08% of the adult female scales dead from natural causes and natural enemies during the

[1]This term is used in this note to cover all causes of mortality other than insect parasites, predators and freezing.

[2]Calculation of two decimal places has been a routine practice in our studies. Special significance is not claimed here.

month preceding the cold weather. Observations on 2489 adult insects on February 2 and 8, following the freeze, showed but 2 alive, a mortality of 99.91% and neither of these living females was producing progeny. During the examinations at this time not a living crawler was seen and only 36 eggs which were judged to be normal.

The studies of the *dictyospermum* scale, *Chrysomphalus dictyospermi* (Morg.) collected at New Orleans, La. on camphor leaves on the 4th and 9th of February 1924, showed 10 living scales in a total of 2428, a mortality of 99.58% while before the freeze only 22.16% of the adult female scales were dead. Mortality among the eggs and crawlers was also very high, only three viable eggs and one active crawler being found during the examinations, and all producing females were dead.

All material used in the observations was taken from living plants and every effort was made to represent normal conditions.

Since *Chrysomphalus aonidium* and *dictyospermi* are primarily leaf-infesting coccids and many of their favorite host plants are completely defoliated, this condition, combined with the almost complete mortality from freezing, seems to have temporarily eliminated these species from the list of economic insect pests in New Orleans. However, the apparent greater resistance to cold of *Pseudaonidia duplex* (Ckll.) seems to add to its possibility as a national economic pest.

THOS. F. CATCHINGS and W. D. WHITCOMB,
U. S. Bureau of Entomology, New Orleans, La.

THIRTY-SEVENTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The thirty-seventh annual meeting of the American Association of Economic Entomologists will be held at Washington, D. C., December 31, 1924 to January 3, 1925, inclusive. Final arrangements with reference to meeting places are not yet completed.

Hotel headquarters for the Entomologists will be at the Harrington, 11th and E Streets. Rates as follows:

Single room, without bath	$3.00
Double room, " "	4.00
Single room, with bath	3.50
Double room, " "	5.00 to 6.00

Members are urged to make reservations as soon as possible.

The Section on Apiculture will meet at 9:30 a. m., Wednesday, December 31st. The section on Horticultural Inspection will meet at 1:30 p. m. on the same day.

The opening session of the general Association will be held at 9:30 a. m., Thursday, January 1st, 1925. On that evening at 8 o'clock the meeting of the Insect Pest Survey and Extension Entomologists will be arranged.

Applications for membership should be filed with the Secretary as soon as possible and should be accompanied with fee of $4.00. Blanks can be secured from the Secretary or the Chairman of the Membership Committee.

C. W. COLLINS, *Secretary, Melrose Highlands, Mass.*

SECOND ROCKY MOUNTAIN CONFERENCE OF ENTOMOLOGISTS

We felt that the first Rocky Mountain Conference of Entomologists held in Pingree Park, Colorado, last year was quite a success, but the one held this year, August

18–23, in the same place far excelled in attendance and in the interesting program. Twelve states were represented, and the entire group, including the families of the various entomologists, numbered fifty. Everyone entered into the spirit of the occasion with the result that all left very much better acquainted and feeling that they had not only had a very interesting and profitable meeting, but that it was as well a very pleasant vacation. We had some tireless collectors of both insects and fish, which resulted in many of both being taken.

A very interesting part of the program was a ten-minute impromptu report on the insect conditions in the twelve states represented. The following are some of the principal subjects that were discussed. All of the papers and discussions were very informal and for that reason proved the more valuable.

Are Insects Animals?—Dr. Wm. A. Riley
Alfalfa Stem Nematode—Dr. C. P. Gillette
Colorado Wild Flowers—Miss Caroline Preston
The Pea Aphis as Affecting Alfalfa—Dr. R. C. Smith
Pea Aphis Predators— C. L. Fluke
Notes on Cicadae—R. H. Beamer
Notes on Homoptera—Dr. Paul B. Lawson
The 1924 Campaign for the Control of the Alfalfa Weevil in Idaho—F. E. Whitehead
The Alfalfa Weevil Situation in Colorado—J. H. Newton
Sugar Beet Insect Problems in Colorado—A. C. Maxson
Sugar Beet Insect Problems in Utah and Idaho—E. G. Titus
Extension Entomology—C. R. Crosby
The Long Time Extension Program—Otis Wade
How to Determine the Hessian Fly Free Date—Dr. C. J. Drake
Improvement of Spray Practices for Codling Moth Control—J. H. Newton.

This program does not begin to represent the variety of subjects that were discussed during the week. Time did not permit of a number of papers that were prepared, but all felt that the informal discussions had been invaluable.

The various contests and impromptu entertainments served to get all acquainted. Dr. C. R. Crosby won the prize for the best mustache grown during the week, but this is being contested by C. L. Fluke on the grounds that the points of brilliancy and area were given too much weight by the judges.

It was unanimously voted to hold the Conference again next year at the same place and at approximately the same time of the year. The officers elected were C. P. Gillette, Chairman, C. J. Drake, Vice-Chairman, and George M. List, Secretary.

GEORGE M. LIST, *Secretary, Second Rocky Mountain Conference of Entomologists*

FIFTH ANNUAL MEETING OF THE NORTHEASTERN ENTOMOLOGISTS HELD AT PHILADELPHIA AND VICINITY JULY 30 TO AUGUST 1, 1924

The Entomologists of Northeastern United States, with a generous number of visitors interested in entomological problems, assembled at the Japanese Beetle Laboratory, Riverton, N. J., on the morning of July 30. The morning was occupied by making an inspection of the laboratory facilities and the experiments under way. The parasite house was of much interest as several thousand flies had recently been bred and liberated in the infested area. These flies were secured in Japan the native

home of the Japanese Beetle, by experts of the U. S. Bureau of Entomology. It is too soon to know just what these parasites will do in this country but much hope is held for their permanent establishment. In the insecticide part of the laboratory a very interesting development was shown in fractioning oil of sassafras. This oil has proved to be decidedly attractive to the Japanese Beetle and has many possibilities when used with a poison bait or in spray materials. For the destruction of the grub of the beetle the carbon bisulfid emulsion developed at the laboratory is still the most dependable and cheapest fumigant. Oil of the American Chenopodium has also been used as well as solutions of arsenate of lead. In the protection of the foliage from attacks of the Japanese Beetle the development of arsenate of lead coated with an insoluble soap seems to be the most effective measure yet tried. The use of flour as a sticker at the rate of two pounds to 50 gallons of spray and three pounds of powdered arsenate of lead gave very good foliage protection in apple, peach and cherry orchards. In connection with the development of attractive oils for the beetles, tests using different colors have been tried as an attractive agent. Up to this time red seems to be the most attractive color.

Lunch was served at the clubhouse of the Riverton Country Club, after which brief reports were presented by Mr. L. B. Smith and members of the staff at the laboratory, concerning different phases of the Japanese Beetle work.

The afternoon was spent in visiting different orchards in the infested territory and observing results of the remedial measures, and examining a number of experimental areas.

In the evening the Entomologists met in joint session with members of the American Entomological Society, in the Auditorium of the Academy of Natural Sciences in Philadelphia. Dr. P. P. Calvert presided at this session and brief addresses were made by Mr. J. M. McKee, Assistant Secretary of Agriculture of Pennsylvania, A. F. Burgess, President, American Association of Economic Entomologists, and J. L. King of the Japanese Beetle Laboratory, who gave an interesting account of his explorations in Japan and Korea. This session was largely attended, the entire seating capacity being occupied.

The following day was occupied in visiting field laboratories and experimental plots. At the Bustleton Laboratory of Pennsylvania State College, interesting experiments were observed in the control of wire worms by fumigating the soil through the use of calcium cyanide before planting. The experiments were not complete but no injury could be noticed in the crop and from preliminary experiments it seems that this is a very promising way of clearing the soil of larvae. At the Willow Grove laboratory of the U. S. Department of Entomology and the Pennsylvania Bureau of Plant Industry, methods of fumigating green-houses were illustrated, in which dust of calcium cyanide was the source of the hydrocyanic acid. This method seems to be quite promising. The rate at which the cyanide is now used is one ounce of the granular form to 100 cubic feet for one hour. It may be that this amount will be considerably lessened and that the time of fumigation will be made longer. A brief, but very interesting stop was made at Valley Forge during the afternoon. Near West Chester, Pa., the orchards in which experiments are now in progress in the use of scalecide and sulphur products as carried on by the Crop Protection Institute, were visited. The scalecide experiments were not far enough advanced to give definite information at present. Several of the colloidal sulphurs and different types of precipitated sulphurs have given apple scab control and seem quite promising as spray materials.

Late in the afternoon the party assembled at the club house of the Westtown School, where a complimentary luncheon was provided by the Delaware-Chester Fruit Growers Association. Prior to the luncheon the entomologists had an opportunity to swim in the river near the club house, and in the early evening the meeting was called to order by Chairman Hodgkiss, who introduced Mr. Wm. Vandergrift, who responded in behalf of the Fruit Growers Association. Dean Stanton of the Westtown School also extended a welcome to the visiting entomologists. A short business session was held and the report of the nominating committee consisting of A. F. Burgess, T. J. Headlee and C. H. Hadley, was received, and nominees for officers for the ensuing year were duly elected as follows: Chairman, E. N. Cory, College Park, Maryland. Secretary, C. H. Hadley, Harrisburg, Pa. It was voted on recommendation of this Committee that the next meeting be held in Maryland. The following resolutions were unanimously adopted: *Resolved*, That the thanks of this meeting be extended to the Philadelphia Academy of Sciences and the American Entomological Society of Philadelphia, for the use of the Auditorium of the Academy and for many courtesies which materially contributed to the comfort and success of the meeting. *Resolved* that the thanks of the meeting be extended to the Delaware-Chester Fruit Growers Association for the generous entertainment provided, and to Dean Stanton of the Westtown School for the courtesies extended and to the local Entomologists and all others who assisted in arranging the program and making this meeting a decided success. Chairman Hodgkiss introduced a number of entomologists who briefly discussed the following topics: W. C. O'Kane, The Work of the Crop Protection Institute. A. F. Burgess, The Oriental Hag Moth. I. M. Hawley, Entomological Problems in Utah, T. J. Headlee, The Oriental Peach Moth. Other speakers included E. M. Cory, W. A. Hooker and Philip Garman. The party adjourned, most of the members spending the night at West Chester, Pa.

On Friday morning August 1, a trip was made by automobile from West Chester through Wilmington, Delaware, crossing the ferry at that point to the New Jersey side. Delaware extended a cordial greeting by having the procession escorted through the city of Wilmington by two members of the State police mounted on motor cycles. At the Sea-Brook farms in New Jersey, experimental plots of the New Jersey Experiment Station were visited, where various sprays and dusts are now being tried in an attempt to control the Oriental Fruit Moth. The plots seem to be fairly free from the attack of the larvae of the moth but the season is hardly far enough advanced to make any definite statements. It was pointed out by Mr. L. A. Stearns in charge of these plots, that early spring cultivation has much to do with the number of emergences of the moths wintering over in the soil. In a cage in which no cultivation took place sixty moths emerged from under one tree, while in a cage in which plowing and harrowing was done no moths emerged. An estimate was made that 75% of the larvae found wintering on or in the ground were destroyed by thorough cultivation; the Oriental Moth is unable to emerge when buried in soil three inches deep. At Glassboro, orchards were visited in which coated arsenate of lead was used in the regular spray schedule and the use of this insecticide in general orchard practice seems promising. Through the courtesy of Dr. T. J. Headlee, a number of the entomologists had an opportunity of visiting the cranberry growing section of New Jersey after the orchards at Glassboro were examined. The other members of the party returned to Camden and Philadelphia.

Nearly a hundred attended the meeting and all were well pleased.

The following is a partial list of those present.

A. L. Quaintance, Washington, D. C.; J. R. Eyre, North East, Pa.; J. R. Stear, Chambersburg, Pa.; David E. Fink, Riverton, N. J.; C. M. Craighead, Guersuey, Pa.; Dwight F. Barnes, Melrose, Mass.; P. R. Myers, Carlisle, Pa.; H. B. Seaver, New Brunswick, N. J.; L. R. Cagle, Leesburg, Va.; G. M. Vunderhill, Richmond, Va.; H.W. Wenzel, Philadelphia, Pa.; H. Hornig, Philadelphia, Pa.; A.B. Champlain, Harrisburg, Pa.; Charles Weigel, Washington, D. C.; Charles Doucette, Willow Grove, Pa.; C. H. Hadley, Harrisburg, Pa.; F. L. Holdridge, Lancaster, Pa.; Ernest N. Cory, College Park, Md.; H. A. Aimes, Bound Brook, N. J.; C. W. Collins, Melrose Highlands, Mass.; C. E. Hood, Melrose Highlands, Mass.; C. W. Minott, Melrose Highlands, Mass.; Saul Phillips, Albany, N. Y.; W. S. Hough, Winchester, Va.; Frank H. Lathrop, Poughkeepsie, N. Y.; A. C. Baker, Washington, D. C.; M. R. Ross, Vineland Sta., Ontario, Canada; Louis A. Stearns, New Brunswick, N. J.; Theo L. Bissell, Westover, Maryland; Fred H. Worsinger, Jr., Holmesburg, Phila., Pa., A. W. Buckman, So. Langhorne, Pa.; M. P. Zappe, New Haven, Conn.; Q. S. Lowry, Boston, Mass.; J. M. McKee, Harrisburg, Pa.; V. I. Safro, New York, N. Y.; M. T. Smulyan, Melrose, Mass.; C. W. Stockwell, Riverton, N. J.; Edward L. Crabbe, Toms River, N. J.; H. B. Scammell, Toms River, N. J.; Charles S. Beckwith, New Brunswick, N. J.; Ray Hutson, New Brunswick, N. J.; W. C. O'Kane, Durham, N. H.; C. R. Orton, State College, Pa.; G. W. Howard, Albany, N. Y.; H. L. McIntyre, Albany, N. Y.; H. L. Blaisdell, Melrose, Mass.; G. A. Smith, Boston, Mass.; C. C. Wagoner, Highland, N. Y.; R. B. Friend, New Haven, Conn.; J. A. Hambelton, Washington, D. C.: Reginald Wooldridge, Melrose, Mass., John T. Ashworth, Danielson, Conn.; A. E. Stene, Kingston, R. I.; Dettman W. Jones, Arlington, Mass.; D. C. Blanke, New York, N. Y.; William W. Chafman, 134 So. 2nd St., Phila., Pa. P. D. Sarders, College Park, Md.; B. G. Pratt, New York, N. Y.; C. F. W. Muesebeck, Melrose, Mass.; William Moore, New York, N. Y.; I. M. Hawley, Logan, Utah; I. L. Sherman, Newport, R. I.; T. L. Guyton, Harrisburg, Pa.; H. I. Winchester, Melrose Highlands, Mass.; Philip Garman, New Haven, Conn.; C. C. Hamilton, College Park, Md.; H. E. Hodgkiss, State College, Pa.; E. R. Van Leeuwen, Riverton, N. J.; Lorran B. Smith, Riverton, N. J.; Philip P. Calvert, Philadelphia, Pa.; A. F. Burgess, Melrose Highlands, Mass., J. L. King, Riverton, N. J., B. R. Leach, Riverton, N. J., W. Rudolf, New Brunswick, N. J.; C. C. Hill, Carlisle, Pa.; Wm. A. Hooker, Washington, D. C., Wm. R. Walton, Washington, D. C., Chas. K. Hallowell, Philadelphia, Pa.; Thos. J. Headlee, New Brunswick, N. J.; Thos. B. Symons, College Park, Md.; Js. Fine c/o Jas. Good, Inc., Philadelphia, Pa.; A. B. Wells, Bryn Athyn, Pa.; F. M. Trimble, Harrisburg, Pa.; Geo. F. Johnson, Harrisburg, Pa.; H. B. Kirk, Harrisburg, Pa.; R. A. Sheale, Providence, R. I., and Carl Ilg, New Brunswick, N. J.

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OCTOBER, 1924

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication, at $3.00 per page for all matter in excess of six printed pages; in the case of other matter, the maximum of 2,500 words is still operative. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded or the proof returned, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

One hundred separates or reprints at $2.00 per page or plate. Additional hundreds or less, 4 pages or less, $1.00; 5-8 pages, $1.50; 9-12 pages, $1.75; 13-16 pages, $2.00; 17-24 pages $3.00; 25-32 pages, $4.00. Covers suitably printed on first page only, 100 copies, or less, $4.50; additional hundreds, or less, $1.75. Plates inserted, $1.75 per hundred, or less. Folio reprints, the uncut folded pages (50 only), sixteen page signature, or less, $3.00.

There is perhaps no phase of economic entomology requiring more discretion in its administration than that relating to plant quarantines. The conference of Federal and State officials last April summarized in our issue for June 1, pages 431–433, formulated a program which leaves little to be desired in the way of a working agreement. Recent advices from the chairman of the conference informs us that all the States in the Union and in addition Porto Rico, Guam, Hawaii and British Columbia have now ratified the agreement. This is a notable step in the right direction and should be followed as soon as possible by such modifications in regulations and practices as to put it into full effect. Even then there will be a multiplicity of nice points requiring decision from time to time.

The report of the Rockefeller Foundation for 1923 contains an account of the attempt to eradicate yellow fever from Brazil and records an absence of cases from Mexico, Central America, Ecuador and Peru. It suggests the ultimate eradication of this scourge from the entire world. The report also discusses the malarial control work started in 1916, special attention being given to rural areas. Last year special malarial investigations were carried on in the United States, Brazil, Nicarauga, Palestine, Philippine Islands, Salvador and Porto Rico. The work of the Foundation, world wide in scope, affords additional proof that under ordinary conditions many communities can reduce malaria to an almost negligible point and at a per capita cost within the limits of local taxation. These great benefits to humanity are striking illustrations of applied or economic entomology, since the control of

both yellow fever and malaria is dependent upon the control of the carrier mosquitos. Can wealth and ability do better than make possible the alleviation of human suffering? The Foundation is one of the noblest conceptions of man. All honor to its founder and his associates.

The Rensselaer Polytechnic Institute, located at Troy, N. Y., celebrated its hundredth anniversary this month. It is the oldest engineering school in the country. Two items of general interest though apparently of little concern to entomologists until we turn to the early history of the institution and find that not only did it recognize the natural sciences but actually gave work in entomology. Ebenezer Emmons, the author of an extended general work on New York insects published in 1854, was graduated in 1826 and Asa Fitch, the first "official entomologist" in the United States received his degree in 1827. The work of the latter is too well known to require more than mention. The character of his work shows that sound training in the fundamentals, even if but little of it relates directly to insects, makes possible the interpretation of many mysteries presented by the Hexapoda. The Rensselaer Polytechnic Institute, through Fitch, profoundly influenced the development of economic entomology in this country. It is fitting that we recognize the debt owed to men in technical schools who gave incidental training in entomology at a time when little training in natural philosophy was considered sufficient.

Reviews

Manual of Tree and Shrub Insects. By Ephriam Porter Felt, 382 pages, 256 figures, The Macmillan Co., New York, 1924, Price $3.50.

A compact and comprehensive manual of shade tree insects has long been needed. Packard's Fifth Report of the U. S. Entomological Commission published in 1890, contained a vast amount of information, much of it descriptive, but was arranged in the form of a catalogue without giving a birds eye view of the subject, or the proper perspective. Of course the control measures mentioned in Packard's work are now mostly obsolete. Dr. Felt's two-volume work, "Insects Affecting Park and Woodland Trees" published in 1905-6, has for nearly twenty years been a standard reference work in every entomological library, but it was too large and cumbersome to be convenient for ready reference. Then in 1918 came Houser's Bu'etin 332 of the Ohio Agricultural Experiment Station on "Destructive Insects Affecting Ohio Shade and Forest Trees," which answered the purpose for a time, though I am told that it can no longer be supplied.

Therefore the appearance of a new book for which there is a need is an occasion for rejoicing: doubly so when its author is one of the best authorities in this country on

the subject. Dr. Felt's new book is one of the Rural Manuals and is of convenient size and generally attractive make-up. It is arranged in three parts: Part I contains general information about the structure, transformations and origin of insects, a list of introduced pests, literature, and accounts of the natural checks and artificial methods of controlling insect pests. Part II contains a brief account of each of the more important shade tree insects grouped according to the particular kind of injury which they cause. Part III deals in a similar manner with forest insects, and Part IV is a systematic account of the more important orders of insects, each order being illustrated by a few species connected with trees or shrubs.

In any work of this size and scope, much must be omitted, and many species included by mention only. Probably no two entomologists would agree on just what species should be included or their relative importance. Nevertheless, the critical reader may wonder why twenty-two pages are devoted to "Plant Galls and Gall Insects" when only twenty pages are given to "Scale Insects" and twelve to "Plant Lice or Aphids." There may also be some difference of opinion about the value of mentioning in a popular work a large number of forest bark beetles about which little or nothing is known, and which can be identified only by specialists. Some errors are bound to appear in a work of this sort (See Figure 131, duplicated in Figure 186) but these can be corrected in subsequent editions. The casual reader in looking over the volume and noting the references may get the idea that the book was written for the people of New York State, or that most of the work on shade tree insects has been done by its author. In my opinion the author's greatest sin lies in giving so many references to his own publications and overlooking or omitting a number of rather important ones published elsewhere. For instance on page 53 at the end of the account of the Bronze Birch Borer, Cornell Bulletin 234 by Slingerland might well be cited as it probably represents as much original work as either of those mentioned, and perhaps more. Citation of references more widely scattered would make the book more useful to readers over a wide geographical area. So far as is possible such citations should refer to publications making some contribution to a knowledge of the subject. Even in the systematic portion, such papers as Funkhouser's on the treehoppers and Fulton's on the tree crickets are omitted.

In spite of the possible criticisms mentioned above, Dr. Felt's book will prove a very useful volume and he should be congratulated by all entomologists on his accomplishment.

W. E. BRITTON

Guide to the Insects of Connecticut, Part IV, the Hemiptera or Sucking Insects, by W. E. BRITTON and COLLABORATORS. Connecticut State Geological and Natural History Survey, Bulletin No. 34, pages 1 to 807, plates 1 to 20, 1923.

This is an extended distributional and descriptive account with numerous keys, of the bugs of Connecticut prepared under the direction of Dr. Britton in collaboration with a number of experts, mostly well known, in the different groups, namely, Messrs. Abbott, Baker, Barber, Davis, DeLong, Funkhouser, Knight, Maxson, Osborn, Parshley, Stearns, Torre-Bueno, Van Duzee, Wilson, and Miss Patch. This publication is one of a series, the first being a general account by Dr. Britton, the second a discussion of the Euplexoptera and Orthoptera of Connecticut by Mr. Walden, and the third, as voluminous as the fourth, an account of the Hymenoptera or

wasp-like insects of Connecticut. The last, like its successor, was prepared through the collaboration of a group of experts. There is, in addition, a check-list of the insects of Connecticut by Dr. Britton, all published as bulletins of the State Geological and Natural History Survey.

This series, with numbers presumably to follow, affords a most substantial basis for further investigations, since it is well recognized that the classification and description of adult or perfect insects forms only a part of the entomological information which should be available. The economic entomologist, in particular, must know the immature stages and until these have been discovered and carefully studied in relation to plants and other animals, it can scarcely be claimed that our insect fauna is well known.

It is a source of regret on the reviewer's part that these works could not have been given a wider scope and have treated of the fauna of the northeastern United States, since many of the genera and species found in Connecticut occur over a much wider area. The reviewer would also suggest the advisability of more illustrations designed especially to give the general character of the adults and so far as possible, of the immature stages. Such figures would add greatly to the value of this series for the amateur entomologist and prove no small factor in awakening interest among those with inclinations toward natural history.

Dr. Britton is to be congratulated upon his progress in making known the Insects of Connecticut through this series of publications. There is certainly no local scarcity of insects. It may be stated in conclusion that corrections and additions to the volume on Hemiptera are now being published and will be sent on request to everyone who has received a copy of the work.

E. P. FELT

Current Notes

Mr. F. E. Whitehead has been appointed extension entomologist and associate professor of entomology at the University of Idaho.

Dr. F. C. Bishopp of the Dallas, Texas, Laboratory of the Bureau of Entomology, visited Omaha, Nebr., July 2, to appear as an expert witness in an insecticide case.

Mr. Vernon R. Haber has been appointed an Assistant Professor in Zoology at Pennsylvania State College, State College, Pa.

Mr. G. L. Davis has been appointed deputy nursery inspector at the Missouri Station in place of O. C. McBride who resigned to accept a position at the Minnesota Station.

On June 3, 1924, the degree of Doctor of Philosophy was conferred by the State University of Iowa on J. L. Horsfall, Associate Professor of Economic Entomology at Pennsylvania State College.

Mr. H. L. Weatherby of the Bureau of Entomology recently returned from a scouting trip for the Mexican bean beetle through Georgia and South Carolina. At the present time he is scouting in Virginia and West Virginia.

Mr. H. G. Barber, Roselle, N. J., was employed during the month of July as a specialist in Hemiptera at the U. S. National Museum, and during this time he arranged and determined the Nearctic collection of the family Coreidae.

Mr. J. U. Gilmore, of the Tobacco Insect Laboratory of the Bureau of Entomology at Clarksville, Tenn., visited Dillwyn, Va., recently for the purpose of investigating damage to young tobacco plants by an undetermined species of insect.

Mr. J. R. Horton, in charge of the Wichita, Kans., field station of the Bureau of Entomology, was called into consultation on account of the grasshopper outbreak in Oklahoma during early July. At the present writing the situation seems to be under control.

According to *Science*, at the University of Minnesota there has been organized an expedition to the Hawaiian Islands to study the marine fauna and flora. Doctors W. A. Riley, Royal N. Chapman and W. E. Hoffman will represent the departments of Entomology and Zoology.

Dr. L. O. Howard, Chief of the Bureau of Entomology, spent several days in southern California, prior to his departure for Honolulu, visiting the Bureau stations at Alhambra and Riverside, and consulting with the various entomologists, both Federal and State, located in that vicinity.

Mr. W. J. Phillips of the Bureau of Entomology visited Greensboro, N. C., July 4, to investigate an infestation of the wheat jointworm, and found a very abundant occurrence of this insect in that vicinity. An infestation of 100 per cent. was found in one field.

According to *Experiment Station Record*, Mr. A. L. Strand who recently resigned as assistant extension entomologist at Pennsylvania State College, has been appointed assistant entomologist at the Minnesota University and Station vice Dr. J. R. Parker who has returned to the Montana Station as associate entomologist.

Visitors to the Bureau of Entomology laboratory at Fort Valley, Ga., during the last month, to observe the work under way, included a group of Tennessee peach growers headed by the horticulturist of the University of Tennessee and several from South Carolina, Alabama, and Virginia.

Mr. J. E. Graf, for many years in charge of field operations in connection with Truck Crop Insect Investigations in the Bureau of Entomology, and for some months Entomologist Acting in Charge of these investigations, has been selected as head of the division, effective June 1, 1924.

Injury to elm foliage in southern Quebec proves to be the work of *Kaliofenusa ulmi* Sundewal, the Imported Elm Leaf Miner. The distribution of the injury has not yet been determined but is reported to cover a very large area in the southern part of Quebec province.

Mr. L. H. Worthley, in charge of corn borer control, left Arlington, Mass., during the week of July 25, going to Cleveland, Ohio, where he was located for several weeks to supervise the initiation of the scouting and quarantine work in the Lake regions. He visited New Haven, Conn., on September 3.

Mr. M. R. Smith, assistant entomologist and ant specialist of the Mississippi State Plant Board has obtained a leave of absence effective September 1st in order to pursue post graduate work at the University of Illinois, leading to the degree of Doctor of Philosophy.

A co-operative project between the Bureau of Entomology and the Bureau of Standards has been inaugurated, having for its object a thorough study of the elec-

trical effects in insecticide dusts. V. E. Whitman, of the Bureau of Standards, has been assigned to the problem. The field work will be carried on at Tallulah, Ia.

Mr. John R. Greeley was employed temporarily at the U. S. National Museum, for the last fifteen days in June assisting Mr. McAtee in arranging part of the Hemiptera collection. During the remaining portion of the summer season Mr. Greeley will work under the Biological Survey, and in the fall will return to Cornell to carry on his university studies.

Mr. James Zetek and family of Panama, visited the U. S. National Museum recently. Mr. Zetek has collected a great deal of fine material which has been sent to the Museum for identification and addition to the collection, and has spent considerable time collecting nests, termites, and wasps, and also a series of some of the rare Panamanian ants.

Mr. J. R. Horton, Entomologist in Charge of the Wichita, Kansas, laboratory, and A. F. Satterthwait, Entomologist in Charge of the Webster Groves, Mo., laboratory, attended the meeting of entomologists and agriculturists who met at Kansas City, Mo., in May to discuss and put into operation methods of control for chinch bugs and the Hessian fly in Kansas, Missouri, Nebraska and Oklahoma.

Dr. W. M. Mann of the Bureau of Entomology sailed for Europe on July 19, to be gone for several months. He will go to Spain in connection with some work for the Federal Horticultural Board. He also intends to visit Dr. Wasmann, the eminent Dutch entomologist, at St. Ignatius Kollege, Valkenburg, Holland, for the purpose of studying his collection of ants and beetles.

Dr. F. C. Craighead, of the Bureau of Entomology, left Washington on June 19 for an extensive trip to inspect the work at the various Forest Insect field stations, and also the co-operative work being conducted at the Forest Service experiment stations; both the Kaibab Project in Utah and the Southern Oregon-Northern California Project, the largest bark-beetle control projects ever instituted by the Government, will be inspected.

Mr. C. H. Popenoe, Bureau of Entomology, in charge of the truck-crop insect work at the Silver Springs, Md., laboratory, visited Pomeroy, Pa., and vicinity to investigate an outbreak of insects in mushroom houses. It was first reported that mites were the cause of the trouble, but upon investigation Mr. Popenoe found that springtails were the principal insects concerned. Co-operative experiments with the mushroom growers have been initiated.

Messrs. Kenneth Auden and A. R. Graham were reappointed as Insect Pest Investigators for the Entomological Branch, Canadian Department of Agriculture, and reported for duty, the former at Vernon, B. C., May 15, and the latter at Aylmer, Quebec, June 1. Mr. R. S. Hawkins, temporarily appointed as Insect Pest Investigator, reported for duty at Fredericton, N. B., on May 28. Miss D. F. Forward appointed temporary laboratory assistant, began her work on June 24.

Since Dr. McDunnough took up the study of the Ephemeridae several years ago, he has described 59 species, the types of which are deposited in the Canadian National Collection. This collection now contains representatives of over one hundred and fifty North American species (about two-thirds of the known species from this region) and is without doubt one of the most complete collections of North American May flies in existence.

The corn borer investigational work under way at Sandusky, Ohio, almost completely escaped the effects of the terrific storm which swept over that locality in the latter part of June. The most serious result of the storm was the partial wrecking of one of the motor boats assigned to the corn borer control work, which was capsized and sunk in shallow water. Arrangements have been made to raise and repair the boat.

The U. S. Civil Service Commission announced an examination for assistant entomologists, applications closing August 12. This examination is for the purpose of preparing a list of eligibles to fill vacancies in the Bureau of Entomology at an entrance salary of $2,400.00 a year. The duties of the position are to conduct experiments with insecticides in the control of Japanese beetle grubs, and in the utilization of bacterial and fungous diseases against the Japanese beetle.

During the month of July, Dr. W. D. Funkhouser returned to the U. S. National Museum the last lot of Membracidae belonging to the Goding collection. The Goding collection had been sent to Dr. Funkhouser for study in three different lots. Dr. Funkhouser has kindly examined each specimen, corrected the identification, and prepared a very complete report, so that it will be possible to incorporate this collection with the rest of the Museum material of the family Membracidae.

Mr. J. S. Houser of the Ohio Agricultural Experiment Station was a visitor at the Vincennes, Ind., laboratory of the Bureau of Entomology on June 30 and July 1. Mr. Houser was completing a trip through the fruit sections of Arkansas, Missouri, Illinois and Indiana for the purpose of making at first hand a study of the San Jose scale situation and the striking control of the scale which had been obtained by the use of lubricating-oil emulsion.

Mr. J. R. Douglass of the Bureau of Entomology, who is conducting experiments on the Mexican bean beetle at Estancia, N. Mex., reports that the beetle injury is greatest near the mountains in which the insects hibernate—the heaviest damage being caused to bean plantings opposite the mouths of canyons. From these data Mr. Douglass believes that on emerging from hibernation, the beetles follow the canyons on their way to the large valleys in which beans are grown. Flight tests are now being conducted.

Messrs. August Busck and Carl Heinrich left Washington for Amherst, Mass., on June 26, to pack the collection of Microlepidoptera formed by the late Dr. C. H. Fernald. The U. S. Department of Agriculture has recently purchased this collection from Dr. H. T. Fernald to be added to the already extensive collection of Microlepidoptera. The collection contains not only the Fernald types, but also much valuable material identified by the older microlepidopterists, and will be one of the finest additions to the collection of Lepidoptera in recent years.

Dr. M. W. Blackman, Professor of Entomology at Syracuse University, has been working since June 15 in the Division of Insects, U. S. National Museum, on the collections of bark-beetles belonging to the superfamily Scolytoidea. It is hoped that Dr. Blackman will be able to rearrange the entire collection, placing most of it in trays, and probably have an opportunity to do critical work on one or two smaller groups. He brought with him the collection of the subfamily Micracinae, which he has critically studied during the last four months.

Prof. George A. Dean of the Bureau of Entomology visited Boston July 6 for the purpose of inspecting the northern edge of the corn borer infestation in Maine and

New Hampshire. It was observed that corn was very small at that time, and because of the backward season but little evidence of infestation was found. On July 19, Prof. Dean left Washington for a visit to Manhattan, Kan. On his return trip he visited several field laboratories in the Middle West and the corn borer scouting and quarantine work in the Great Lakes region.

Mr. A. F. Satterthwait of the Webster Groves, Mo., laboratory of the Bureau of Entomology made an extended trip by auto during May in Missouri, Kansas and Nebraska. He not only had an opportunity to study the insect collections at the Universities of Missouri and Kansas, the Kansas State Agricultural College, and the Warren Knaus collection of Coleoptera at McPherson, but he also had an opportunity to do considerable collecting in the field. He was accompanied on some of the collecting trips by Dr. William Hayes, of the Kansas State Agricultural College, and Warren Knaus, of McPherson, Kansas.

A shade tree conference to consider some of the problems connected with the care and protection of shade trees was held at Stamford, Conn., August 25 and 26. The invitations to attend this conference emanated from the Tree Protection Examining Board of Connecticut, and included a small number of scientific men and a few practical tree surgeons known to be interested in the objects of the conference. Entomologists present were Dr. E. P. Felt, Albany, N. Y.; Mr. A. F. Burgess, Melrose Highlands, Mass.; W. O. Hollister, Kent, Ohio; W. O. Ellis, Boston, Mass.; Dr. Philip Garman and Dr. W. E. Britton, New Haven, Conn.

Motion pictures were taken by the U. S. Department of Agriculture under Mr. St. George's supervision, of logging operations in the woods and mill at Charleston, S. C., showing the approved methods of handling pine to prevent worm-hole injury. At Savannah and Clyo, Ga., and Vicksburg, Miss., additional motion pictures were taken illustrating methods of handling gum to prevent pinhole and wormhole injury. Several pictures were made at Vicksburg, showing methods of racking and piling lumber to prevent this character of injury. At Vicksburg extensive co-operative studies are being conducted to determine the best methods of cutting cypress to prevent borer attack.

Dr. B. A. Porter of the Vincennes, Ind., Laboratory of the Bureau of Entomology, attended a blueberry maggot conference at Bangor, Maine, on July 18. The conference was called by the National Canners Association for the benefit of the blueberry canners of Maine, to consider possible methods of preventing the presence of maggots in canned blueberries. The matter was very thoroughly discussed, but the present knowledge of the problem was not sufficient to warrant final conclusions or recommendations. The insect involved has been considered to be *Rhagoletis pomonella* Walsh, the well-known apple maggot, although the form attacking the blueberry is probably a distinct biological strain.

The Sugar Cane Insect Laboratory of the Bureau of Entomology will move on October 1st from Audubon Park, New Orleans, to Rooms 6 and 7, Wilson Building, 8200 Oak Street, New Orleans, La. T. E. Holloway and W. E. Haley are permanent employees assigned to this Laboratory, and during the fall months, L. P. O'Dowd and D. D. Ewing, Jr., will be employed as temporary assistants.

Mr. R. A. St. George of the Bureau of Entomology left Washington May 28 to conduct co-operative studies relating to the prevention and control of insects affecting crude forest products. At Portsmouth, Va., extensive studies are being conducted

to determine the effectiveness of sulphur dioxide gas, orthodichlorobenzene, and creosote in preventing and checking the attack of ambrosia beetles, or pin-hole borers, in select grades of cypress which are used for partitions in batteries furnished automobiles and airplanes. At High Point, N. C., considerable control work was done in treating infested rustic furniture with orthodichlorobenzene. About a week was spent at Asheville, N. C., with A. H. MacAndrews, who is conducting life-history studies of bark-beetles attacking pine trees, and the seasonal cutting of various trees.

The following appointments to the Bureau of Entomology have been announced: Temporary appointments: Mexican bean beetle, H. L. Weatherby, Prof. D. M. DeLong, Field Assistants; Rodney Cecil, Junior Entomologist, Norman Allen, Roy H. Stansell, Junior Entomologists, and Calvin J. Boal and Horace Richman, Field Assistants, truck crop insect investigations; John A. McLemore, Junior Entomologist, sweet potato weevil eradication; Cecil C. Wilson, Junior Entomologist, cereal and forage crop insects, Sacramento, Cal.; Hiram G. Burt, Junior Entomologist, jointworm investigations, Charlottesville, Va.; Adan Celaya, seed chalcid investigations, Yuma Valley; David Dunevan, wireworm investigations, Yakima Valley, Wash.; Wm. J. Reid, Junior Entomologist, truck crop insect investigations,Chadbourn, N.C.; Wm. M. Mingee, Junior Entomologist, sweet potato weevil eradication, Gulf Coast Region, S. F. Potts, Mexican bean beetle, Ohio.

Mr. H. R. Bryson has been appointed Assistant Entomologist in the Department of Entomology, Kansas State Agricultural College

Apicultural Notes

Mr J. E. Eckert of State College, North Carolina, was a recent visitor at the Bee Culture Laboratory.

Mr. W. J. Nolan attended the meeting of the North Carolina State Beekeepers' Association at Winston-Salem, September 10.

Mr. E. L. Sechrist was in attendance at the Maryland State Fair at Timonium in connection with the educational exhibit in beekeeping, September 1.

Professor Frances Jager of the University of Minnesota, has been selected as judge of the honey exhibit for the Mid-West Horticultural Exposition, which will be held in Waterloo, Iowa, November 11–16.

Mr. George Harrison, vocational instructor in bee culture at the University of Maryland, College Park, under Prof. E. N. Cory, has resigned and accepted a position as manager of the G. B. Lewis Company, Lynchburg. Virginia.

Gail M. Creger, a vocational student at Iowa State College, Ames, who took apiculture under Prof. F. B. Paddock, has accepted a position as manager of the G. B. Lewis Company of Wichita, Kansas.

The summer meeting of the State Beekeepers' Association of North Carolina was scheduled to be held at Winston-Salem on September 10. The secretary is J. E. Eckert, State College Station, Raleigh, N. C.

Dr. James A. Nelson, Mt. Vernon, Ohio, formerly connected with the Bee Culture Laboratory of the Bureau of Entomology, recently spent a few days at the laboratory arranging for the publication of his paper on the morphology of the honey bee larva.

Before Dr. and Mrs. Phillips left the village of Somerset, a suburb of Washington, the people of the town tendered them a farewell reception at which practically every resident was in attendance. Mrs. Phillips and the boys left for Ithaca, N. Y., on August 27, and Doctor Phillips will take up his new duties in Cornell University shortly before October 1.

Mr. E. W. Tschudi has left the Bee Culture Laboratory to return to his work at the Johns Hopkins University. Dr. Bruce Lineburg has resigned to accept the professorship in biology at Lake Forest College, and L. M. Bertholf will soon leave to attend the Johns Hopkins University. Carlton Burnside will attend the graduate school of the University of Michigan this coming winter.

Mr. Ph. J. Baldensperger, delegate from France to the International Congress at Quebec, will shortly visit various points of interest in beekeeping in the United States. Communications to him may be addressed to the Bee Culture Laboratory of the Bureau of Entomology. Mr. Baldensperger has spent many years in Palestine and other eastern countries and is an authority on eastern races of bees.

The VII International Apicultural Congress was held in Quebec September 1 to 4. Delegates were present from France, Italy, Switzerland, Belgium and Peru, as well as from various states of the United States and provinces of Canada. English and French sections were held separately and all papers presented were given at both sections. The proceedings will later be published in both languages. It was decided to leave the arrangement for the time and place of the next Congress to the permanent committee of the Congress and to make an effort to enlist the support of beekeepers from other countries in future Congresses. Following the sessions, excursions were given to various points of interest in Canada.

Mr. James I. Hambleton has been appointed Apiculturist of the Bureau of Entomology, to succeed Dr. E. F. Phillips who has resigned to accept the position of Professor of Beekeeping at Cornell University, October 1. Mr. Hambleton is a graduate of the Ohio State University, where he specialized in entomology and beekeeping. He was in four major offensives in the World War, serving through the grades from private in the hospital corps to first lieutenant in the infantry. He took a course in beekeeping at the Jardin du Luxembourg, Paris, after the signing of the armistice. He was instructor in beekeeping at the University of Wisconsin, both before and after serving in the army, and was appointed apicultural assistant in the Bureau of Entomology in 1921. He is both a practical beekeeper and a trained scientist.

At the annual summer meeting of the beekeepers of Wisconsin held this year at Fond du Lac, August 12 to 14, the beekeepers presented beautiful silver coffee services to Dr. E. F. Phillips of the Bureau of Entomology, and to Mr. George S. Demuth, Editor of *Gleanings in Bee Culture*, in appreciation of their services to Wisconsin beekeeping while they were working together in the Bureau. Mr. Demuth left the Bureau some time ago but has since then attended all the summer chautauquas arranged by the University of Wisconsin. The resignation of Doctor Phillips from the Bureau of Entomology presumably marks the close of the team work of these two men, and for that reason the beekeepers took the occasion to express their thanks in this manner. A silver vase was presented to Prof. H. F. Wilson of the University on the same occasion, in recognition of his labors for the advancement of beekeeping in the State.

Pacific Slope Notes

Professor C. W. Woodworth has returned to the University of California, having finished his work in China.

Mr. Alan P. Dodd, Entomologist of the Commonwealth Prickly-Pear Board, Brisbane, Queensland, is now in Southern California collecting insect enemies of cactus.

Dr. Frank R. Cole of Redlands, Calif., recently visited the U. S. National Museum and examined a number of species in the collection of Diptera.

The University of Southern California conferred the degree of master of science upon Mr. A. O. Larson, June, 1924. Mr. Larson presented a thesis entitled "The Host Selection Principle as Applied to *Bruchus quadrimaculatus*."

Mr. J. C. Hamlin, who was recently transferred from Southern Field Crop Insect Investigations to the Division of Stored Product Insect Investigations of the Bureau of Entomology, has just completed a survey of dried fruit insect conditions on the Pacific Coast, and had located temporarily at Dinuba, California. He will devote considerable time to the subject of vacuum fumigation for controlling dried fruit insects.

Mr. P. H. Timberlake, formerly connected with the Hawaiian Sugar Planters' Experiment Station in Honolulu, and who has resigned to accept a position with the California Citrus Experiment Station at Riverside, Calif., spent the week of June 16 to 23 in the U. S. National Museum, studying types of chalcid flies. Mr. Timberlake was on his way to visit relatives in New Hampshire, and expected to return to Riverside, Calif., where he will be permanently located, about July 15.

According to *Science*, the California Academy of Sciences is sending a collecting party from its department of entomology, in charge of Mr. E. P. Van Duzee, assisted by J. O. Martin, into the southern Arizona mountains to collect and study the Sonoran fauna of the region. They planned to leave San Francisco about July 15 and expected to remain in the field from four to six weeks, visiting the Santa Catalinas, the Huachucas and possibly others of the southern mountains.

After attending the meetings of the Pacific Slope Branch, American Association of Economic Entomologists at Stanford University, June 26 to 28, Dr. L. O. Howard spent several days in southern California, visiting both the Federal and State entomological laboratories in the vicinity. President A. F. Burgess also spent two days in a very rapid survey of the entomological work being done there, paying especial attention to the methods of biological control of citrus pests being carried out under the direction of Prof. H. S. Smith.

After a four months' leave of absence engaged in investigations on Fanning and Washington Islands, Prof. W. B. Herms has returned to active duty in the Department of Entomology and Parasitology of the University of California. On his way back from these islands, Prof. Herms stopped over at Honolulu to attend the meetings of the Pan Pacific Food Conservation Conference to which he was a delegate, returning to San Francisco via the St. Mauri August 12. While on Fanning and Washington Islands, Prof. Herms investigated certain cocoanut pests, mainly the borer, *Diocalandra taitensis* (Guerin) which is responsible for considerable damage on these islands. In addition Herms and his assistant, Mr. Harold Kirby, Jr., Fellow in Zoology, made a general study of the fauna and flora of both islands, particularly

Fanning, which is a typical coral atoll and presents a fertile field for the biologist. Extensive collections of both plants and animals were made for later studies and deposit in the interested museums of the University of California. This material is expected to arrive in San Francisco on the Motor Schooner Doris Crane about the middle of October.

Horticultural Inspection Notes

The Federal Horticultural Board has authorized the inspection and sealing of hold baggage at Honolulu for passengers traveling from Hawaii to Pacific Coast ports. This service is proving popular with the traveling public, transportation companies, and inspectors at ports of entry. It decreases to some extent the inconvenience to passengers during the rush of landing, shortens the time steamers are held in quarantine, and enables inspectors to inspect more thoroughly stateroom and other unsealed baggage.

Mr. H. F. Willard, in charge of the Bureau's laboratory at Honolulu, Hawaii, writes as follows: "Theo. L. Bissell, who has been employed at the Bureau's station at Honolulu as Plant Quarantine Inspector since January, 1921, has been granted a two-year furlough without pay to enable him to do postgraduate work in entomology at Cornell University. Alfred Lutken, a graduate of Mississippi Agricu.tural College, has been appointed to take Mr. Bissell's place and is now associated with Mr. Willard."

Notes on Medical Entomology

Mr. W. E. Dove, of the Dallas, Texas, Laboratory of the Bureau of Entomology, went to Jacksonville, Fla., July 21, to investigate the horse-flies in that State. Incidental to this investigation he is taking up a very interesting piece of work in collaboration with Dr. Kirby Smith of Jacksonville, on a little-known form of dermal myiasis which is present throughout the South. This malady is especially serious in parts of Florida.

Dr. H. G. Dyar of the U. S. National Museum returned July 29 from a three months' trip to the Pacific Coast, where he went in search of the larval stages of two mosquitoes, *Aedes aloponotum* and *Aedes ventrovittis*, which live in the high mountain regions. Dr. Dyar was successful in getting a large number of larvae of *aloponotum*, but did not find that stage of *ventrovittis*, although he found many adults. While in the West he visited Bakersfield, Calif., where mosquito work is being carried on by Major Charles K. Badger.